THE TELEGRAPHIC JOURNAL AND

ELECTRICAL REVIEW.

VOL. XXVI. APRIL 4, 1890. No. 645

CONTENTS:

	PAGE
Safety in Electrical Distribution	365
Arbitration	366
Lightning Conductors (*continued*)	369
On the Excitement of Electricity and Heat in Electrolytes...	371
Electric Lighting at the Universal Exhibition of 1889 (*concluded*)	371
A Synthetic Study of Dynamo Machines (*cont.*) (*illustrated*)	374
The Deptford Station and the Southwark Electric Railway Join Hands	376
The Fawcett Gas Engine	377
A New System of Electric Accumulators and its Accessory Apparatus	377
Polechko's Disc Dynamo (*illustrated*)	377
Notes	378
City Notes, &c. :—London Electric Supply Corporation ...	383
Fareham Electric Light Co....	384
Traffic Receipts	384
Mark Twain's Science	385
Proceedings of Societies :—	
The Institution of Electrical Engineers (*illustrated*) ...	386
Physical Society	390
New Patents	391
Abstracts of Published Specifications	391
Correspondence :—Tinned Copper Wire	392
Dynamo and Motor Design	392
Progress of Electric Lighting	392
The Physiological Effects of Currents	392

SAFETY IN ELECTRICAL DISTRIBUTION.

IN a recent issue of *Industries* Mr. James Swinburne commenced a series of articles on "Safety in Electrical Distribution." Any communication from the pen of this gentleman must command respect, and his utterances on the subject be of considerable value. Dealing first with series arc circuits, the writer points out that for a current to be safe it is not enough that the wires should be perfectly insulated, the public and the companies' servants should be protected against any accidents which might occur through the insulation breaking down. With reference to this it is pointed out that every arc lamp in the market has its framework in contact with the circuit. The writer condemns this as a reprehensible practice, and in this we entirely agree. One reason why this insulation is not carried out is, of course, that, as regards the circuit, such insulation is not required, and to effect it a not inconsiderable addition to the cost of the lamp would be required. Again, everyone knows the dirty state in which insulated fittings are when in an exposed situation, a defect which is not remedied by the usual cleaning with oily cotton waste by the lamp attendant. It is almost certain, therefore, that simply to insert ebonite (or other similar material) in the form of washers or collets to separate the parts requiring insulation would not obviate the evil, as it would probably only insure a false security. The prevention of surface leakage in exposed situations is a problem which has baffled many, though, to tell the truth, no very great efforts have been made to effect a new departure in this direction. Earthing the frame of the lamp, as pointed out, could ensure security; but it is also shown that the arc lamp insulations would always be giving way. No doubt the latter would be the case if the lamps are made as at present, but there seems no reason why an alteration in the general design might not overcome the difficulty. Mr. Swinburne again says that danger of leakage at the dynamo would be considerably reduced if the series working of the field magnets were abandon and separate excitation generally employed. With regard to high tension working, the one argument for which is the smallness of the conductor required, it is urged that 1,000 volts would practically be as economical in conductors as 4,000 volts, if we call to mind the fact that the higher the tension the higher the cost of insulation. This is a point which people are apt to overlook, but it is an important one. Insulation for high tension is not only expensive in first cost, but it is also expensive in maintenance, and it would probably be economical in both respects to use heavier conductors comparatively lightly insulated.

Above all, it is most important that in an installation arrangements be made so that proper tests of the cables can be made quite independently of the fittings. At present we believe this is never done, and, moreover, no attempts are made to effect such a desirable arrangement. If, for any purpose, tests of an installation have to be made, and it is requested that in order to test the cables the latter may be disconnected from the lamps and fittings, the reply is almost invariably—there will be considerable difficulty in doing this, as the ends cannot conveniently be got at. What would be thought of a telegraph cable company who gave a reply like this when they requested a report to be made on the condition of their cables? As Mr. Swinburne suggests, it is quite probable that the numerous accidents which have occurred in the States have to a great extent arisen from the circuits never having been tested, and being taken as right until a breakdown occurred. Mr. Swinburne says that it seems impossible for an arc circuit, if it broke and fell over other wires, to make a contact and cause damage, as the field magnets would lose their magnetism almost instantly, and there would consequently be very little electromotive force available. If separate excitation were always used as suggested to help to prevent leakage at the dynamo it is obvious that the danger created by a broken wire would be seriously increased; indeed, it would be a "dead" certainty.

In speaking of transformers Mr. Swinburne, though a well-known advocate of this system, does not hesitate to say that "there is always the chance of a contact between the primary and secondary circuits," which might result in fires or dangerous personal injuries; and he even argues that in the case of a tension not exceeding 100 volts a sensitive person, who made very good contact, might be seriously injured, if not killed. Possibly a method of obtaining safer insulation, without sacrifice of efficiency in transformers, will eventually be worked out, but the subject seems surrounded with difficulties. Attention is drawn to an important point, and that is that if contact does occur between the primary and secondary, the insulation of the cable is seldom fit to withstand 2,000 volts tension. Until a more perfect method of insulation is devised means of rendering any breakdown harmless are very necessary. The various arrangements suggested for this appear to have counteracting objections; thus Mr. Mordey's proposal to earth the secondary in the middle, it is pointed out, would cause a fire if there was a leak on one lead. Speaking of automatic leak finders, which are arranged to cut any particular house in which a fault occurs out of circuit, the writer somewhat unreasonably argues that "If the light is put out through a fault on the consumer's circuits he has himself to blame, as he is responsible for his leads, and has probably had them put up badly;" it is difficult to see how an untechnical householder, even if he has his work done by a good firm, can possibly ensure that his house shall be perfectly wired. Infallibility, except in the case of his Holiness the Pope, does not exist on this earth. We mentioned that it was argued that there is always a chance of a contact between the primary and secondary. This statement is, however, somewhat contradicted later on by Mr. Swinburne, as he states that "there is no reason why the primary should not be perfectly insulated from the secondary."

Referring to cases where a 2,000-volt circuit is only intermediate and is supplied from transformers fed at 10,000 volts, it is argued that it would be most important to have the 2,000-volt circuit earthed somewhere, especially if the 10,000-volt circuit is itself earthed, otherwise if the 10,000-volt circuit gets into contact with the 2,000-volt circuit it will easily penetrate the insulation of the house transformers, and will run to earth at the houses.

Perhaps one of the most suggestive paragraphs in Mr. Swinburne's articles is the following:—

"There is another source of danger from transformers. If two neighbouring turns of the primary circuit come into contact, or, as more often occurs, if two neighbouring layers come into contact, they act as a short-circuited secondary on the transformer, and grow very hot. The neighbouring insulation is burnt, and more primary turns become short circuited until the primary fuse goes. This is not at all an unlikely contingency, for in many transformers there is a difference of pressure of some hundred volts between the neighbouring layers of primary wire. A 10-horse transformer, for instance, if the fuses are set to go at 15 H.P., will, if this accident occurs when there is no external load on, have 15 H.P. converted into heat in its primary coil before the fuses go. If not provided against, this may easily cause fires, and it is also not unlikely that when the whole apparatus is charring the primary and secondary may make contact, and that, as one fuse goes first when there is a gradual rise of current, they would be left in contact. In America one eminent inventor has patented an arrangement, in which he places his transformers in a sort of stove with a chimney, so that if or when this catastrophe does occur the products of combustion are carried away by the flue without setting the house on fire. In this country all danger will be at an end when the Board of Trade rules are enforced, and transformers are confined in fire-proof cases."

Mr. Swinburne's proposal to prevent gas accumulating in culverts by causing a constant draught to circulate through them, this being effected by having a ventilating post here and there with a resistance (heated by the current) placed in them, is ingenious, but we should doubt the cost being small; the amount of energy required for the purpose would, we imagine, not be inconsiderable.

ARBITRATION.

IN view of the recent labour difficulties, and with the latest proposals for the formation of a Board of Arbitration before us, it may be worth while to recall the result of mediation on the occasion of two of the more notorious strikes. This retrospect is perhaps enhanced in interest by the fact of arbitration having been proposed in the case of the Liverpool dock strike, where certain of the busybodies who so prominently figured as would-be peace-makers in the case of the London docks and the coal porters' strikes, unabashed by their lamentable failures on those occasions, again proposed to rush in where wiser men feared to tread.

It will be remembered that the London dock companies were almost forced into arbitration, the public generally seeming to consider that the dock labourers had a veritable grievance. The immediate consequence of intervention was that the majority of the men returned to work, but scarcely had the difficulty been to all appearances satisfactorily adjusted, and while the Press was actually congratulating everybody on the termination of the struggle in a manner gratifying to all parties, when, without the least warning, a most flagrant breach of the terms mutually agreed to, was committed by the labourers. Precisely the same result attended arbitration in the case of the coal porters' strike, the stipulations of the agreement being contemptuously set aside on the very first occasion which called for an application of their conditions.

It is instructive to observe reasons given for non-compliance with the covenant—on the one hand the men affirmed that certain clauses were ambiguous, they insisted that the intention of some of the stipulations was the reverse to the reading of them as interpreted

by the employers; and further, they declared that issues unforeseen in the drawing up of the compact had rendered impossible the fulfilment on their part of the clauses in question.

On the other hand, the leaders of the "labour movements," on being appealed to in the more flagrant cases of contravention, declared their inability to compel the men to adhere to their engagements, and, with a callousness, scarcely credible, remained passive while promise after promise was broken by their followers.

So far as the men on strike and their leaders and organisers are concerned it is easy to appreciate their readiness to accept an arrangement which, while strictly binding the employers, permits the other party to repudiate whatever clauses or stipulations in the agreement it may subsequently be considered convenient to ignore or set aside.

It is not an exaggeration to say that the practical result of arbitration has invariably been fiasco, yet without this teaching it can be very reasonably argued that the conditions which govern this species of mediation are utterly opposed to an equitable solution of the difficulty. The arbiters depend for their knowledge of the relations existing between employers and employed entirely on *ex parte* statements, and it is a curious fact that far more credence appears to have been given to the representatives of "labour," vague and unsatisfactory as are generally their utterances, than has been granted to the cause of the employers. The exigencies which arise from day to day in all commercial transactions are not invariably alike; the management of one particular business may be—in fact, almost certainly is—utterly different to that of another; and the questions connected with the supply and demand of labour differ according to circumstance and locality.

So far as the sentimental attributes of arbitration are concerned, no doubt a neutral individual would be most likely to exercise an impartial criticism; but he cannot be accepted as an efficient judge when the practical conditions of a business with which he has no acquaintance are under consideration. Far more aggravated are the circumstances when the same individual is called upon to officiate in several disputes where each case may involve dealing with an utterly distinct branch of industry.

Arbitrators, as generally constituted, are far too apt to settle the question in contention by seeking a happy mean. This may be fair enough where there is a difference of opinion as to an interpretation of contract. But in the case, for instance, of a strike for higher wages, arbitration on the plan usually adopted must, whether rightly or wrongly, result in an increase of wage. So that the arbitration may be equally just to masters as to men, it would be only fair that the masters' case should be represented in the adjudication in the form of a proposal to pay the same percentage below the current wages as the men demand to be paid in excess of that amount. A settlement at some figure between these extremes would appear to be more equitable, not that anyone for a moment would believe, should the award fix upon a lower rate than the current wage, that it would at all be likely to be accepted by the strikers, who have hitherto not been conspicuous for a faithful adherence to the conditions imposed by arbitrement.

Leeds and the Electric Light.

SOMEHOW Leeds appears determined to make itself noteworthy in connection with its electric lighting. At a celebrated trial which took place last week, known as the "Salford Gas Scandal," the court had an opportunity, whilst investigating a "gas" case, of seeing how electric light behaved. During the opening of the case the remarks of the learned counsel, we hear, "were rudely interrupted" by the light going out, and at first he was under the impression that it was a "gas vagary," but he found that it was the "new electric light." "The light having became once more brilliant and steady the learned counsel continued his address." He had not proceeded far when the light again became dim, and went completely out. "The court," we learn, "was now in a state of semi-darkness, the only light entering faintly through the glass in the roof, high above, except that which proceeded from a solitary gas bracket on one side of the building." This collapse in a case relating entirely to gas and coal, was certainly very singular and amusing, and there was, we hear, general and hearty laughter as a consequence. Certain apologetic remarks were made by counsel "that they were not always like that in Leeds, and that this was done with the idea of impressing the Salford gentlemen, and to show them how well they could do that sort of thing." The whole history of the electric lighting question in Leeds is of very much the same character and it has already been placed before our readers "how well they can do that sort of thing." That is what the corporation has to show for the many thousands spent in "electric lighting" (?)

The *Electrical Engineer* of New York.

WE are glad to find that this excellent paper is now to appear weekly instead of monthly as heretofore. Messrs. T. C. Martin and J. Wetzler, who have so ably edited another of our American contemporaries, will now conjointly conduct the *Electrical Engineer*, and we wish them the best of success in their congenial occupation. Mr. Martin is, we believe, an Englishman, although personally not so well known in this country as his colleague Mr. Wetzler, who visited England so recently as the autumn of last year. Under their combined influence the *Electrical Engineer*, as a weekly publication, should soon become the leading paper of the eastern part of the United States.

Mark Twain's Science.

THE genial American's latest work, "A Yankee at the Court of King Arthur," can scarcely be called a novel; it is rather a political work in furtherance of the social democratic movement, yet it is a book which will well repay perusal. How this Yankee, a fierce and furious propagandist of anti-monarchical and aristocratic ideas, found himself in the company of King Arthur and the Knights of the Round Table at Camelot, is not for us to say, but he has not been there long, before in the light of the knowledge of the present day he determines to "boss" the whole business. The manner in which he

speedily became second only to the king himself, how he started patent offices, telegraph services, telephone exchanges, and everything known to modern days, must be read to be realised. But there is one thing on which Mr. Clemens's "Yankee" prides himself, and that is the way in which in every instance modern science circumvented the magic of Merlin, or, as he terms it, the magic of fol-de-rol. The choicest example, to be seen on another page, forms a theme from which our gallant defenders, who utilise electricity in warfare, can get no end of the most valuable information. Mark Twain, although a highly successful man, has mistaken his vocation in life; he should have been an electrical engineer.

Woodhouse and Rawson, Unlimited, Limited, and United Limited.

UNDER this title in its issues of March 8th, 14th and 31st, the *Financial Times* gives a sketch history of these companies with comments, and winds up with a recommendation to the shareholders of Woodhouse and Rawson, Limited. The articles are interesting, and we should much like to hear Mr. F. L. Rawson's explanations of the delay in the audit of the accounts to June 30th, 1889, of Woodhouse and Rawson, Limited.

The Institution of Electrical Engineers.

THE letter which we publish from Mr. Sayers, and a request from Mr. Mordey that the remarks attributed to him at a recent meeting of the Institution should be corrected, which has been done in our "Notes," show that there is something not quite satisfactory in these official abstracts with which the technical press must remain contented. Our opinions on the decision which led to the change were given at the time it occurred, and we see no reason to modify the views then expressed.

Medical Electricians in Error.

PROF. GEORGE FORBES points out in our Correspondence columns the difference between the average current over the period of an alternation and the maximum value during the same time, and shows that the use of an induction coil does not give reliable data upon which to base the physiological effects of alternating current dynamo machines.

Magazine Science.

EVERY form of popular literature is bound nowadays to have an article or two occasionally on the scientific topics of the day, and magazines, whether old or new, feel constrained to fall in with the general custom. It would be as well, however, if the editors of such literature would take care that the writers are something more than young men who, from want of experience, are led to making statements and expressing opinions which those of maturer knowledge would have avoided. In the last issue, for example, of *Murray's Magazine*, we have an article on "The Present Position of Electric Lighting," by Mr. A. A. Campbell Swinton, in which we have many assertions which can only be characterised as absurd. We are told that *before the close of the present year* electricity for lighting purposes will be obtainable in all the more important districts of London and in many provincial towns; we then have a number of towns mentioned in many of which, as a matter of fact, the purely experimental stage has not been passed; yet it is stated that in those places the system is in successful operation. For small installations, we are informed that gas and petroleum engines are largely employed; as regards the latter class of machines this is simply not the case, as although they are deserving of large use, up to the present they are but sparingly worked. Coming now to the question of accidents, Mr. Swinton states that "investigations have shown that these reports have in many cases been absolutely devoid of foundation, or gross exaggerations, propagated for commercial reasons by interested persons;" if we were to say that "the *contradictions* of the accidents were gross exaggerations propagated for commercial reasons by interested persons," we should be much nearer the truth; the fatal accidents *have* been authenticated. The statement that the placing of the mains underground secures the public from any possibility of harm is distinctly misleading, as it in no way affects the question of accidents due to transformers being short circuited; it might as reasonably be argued that placing gas pipes underground prevents gas explosions. We are told that all risk of fire due to anything getting out of order may be avoided by having the installation in a house tested once a year by a competent expert. As a matter of fact the test which so-called competent experts take are of comparatively little value, they do not use high power and for this reason their tests are of little value; and again the overheating which may be caused by the working current cannot be detected as likely to take place by any ordinary test. With the last paragraph of the article we can fully agree, viz., "It may be safely said that electric lighting has passed the experimental stage of its existence, and its rapid introduction is now assured.

A Converter Wanted.

THE London Electric Supply Corporation shows a profit of a little over a £1,000 for a year's working, but when one considers the difficulties which will beset the directors when everything is carried on from Deptford, it is doubtful whether even this small sum will rank as profit at the end of another twelve months. The cables have cost over £40,000 already, but we do not hear that the Ferranti mains have justified the expenditure upon them. We had hoped to be able to say something of a favourable nature respecting the future prospects of this corporation, but there does not appear to be anything in the report to the shareholders to justify us in altering or even modifying the views we have so consistently held respecting this 10,000-volt scheme. It is, however, not unlikely that the system of the Corporation will be reconsidered, and a reasonable method of dealing with high tension distribution ultimately adopted, for even those who were among the most sanguine of Mr. Ferranti's supporters must now be very dubious as to the practicability of his ambitious designs; but it is still evident that a powerful converter is required to convince the directors that they should retrace their steps before it is too late. The gist of the whole thing lies in the second paragraph of the engineer's report.

LIGHTNING CONDUCTORS.

By S. ALFRED VARLEY.

(*Continued from page* 343.)

The capability of a Leyden jar discharge to overcome resistance, ought to be, it is thought, directly as the energy statically accumulated. It would therefore seem to follow that the length of wire capable of being deflagrated should increase directly as the energy accumulated in the Leyden battery increases, and as the energy of a statical charge increases as the square of the potential to which the charge is raised; doubling the potential of the charge would, it is thought, increase the length of wire capable of being deflagrated four times, the same law governing disruptive discharges, whether the path of discharge be the molecules of a gas, or the molecules of a metallic conductor.*

The writer would direct attention to the strong analogy that exists between a bullet discharged from a rifle, and a Leyden jar discharge. Both the Leyden jar discharge and the rifle bullet represent the unlocking of energy previously statically occluded. A Leyden jar discharge is theoretically capable under certain assumed conditions of developing a current approaching to the infinitely great, and so also is a moving rifle bullet theoretically capable of developing an infinite amount of force during an infinitely small interval of time. The inertia opposed by a tree to a rifle bullet at the moment of impact is infinitely great, and the bullet *does not* overcome this inertia, instead of doing so it penetrates into the wood, the inertia of the bullet only (speaking practically) being overcome and this not quite suddenly.

The transformation of energy which results from inertia overcome occurs almost wholly in the bullet, whereas the transformation of energy arising out of cohesive force overcome takes place chiefly, if indeed not entirely, in the tree; at the same time the heat developed in the tree as well as that in the bullet represent energy which was occluded in the gunpowder.

If the above analogy holds good then it would seem to follow that the bursting up of a conductor arises out of the cohesive force binding together the atoms of the molecules being broken down, and not to overcoming inertia, and if this be so, the query suggests itself whether magnetism is developed in the conductor when it is deflagrated by a Leyden battery discharge; the query here raised could probably be set at rest by taking a length of platina wire which a given statical charge is capable of deflagrating when in a straight length, and wrapping it into spiral so as to increase its self-induction and then discharging the statical charge through it, or the spiral might be wrapped on a glass tube in which a soft iron core was inserted. If magnetism be developed by a discharge capable of deflagrating a conductor, the inertia would be greatly increased by the iron core the act of discharge would be prolonged and the platina wire not deflagrated.

When a Leyden battery is discharged through a conductor, which it deflagrates, the circuit is completed through an air space and this air space determines the potential at which discharge occurs, for it is the resistance the air molecules oppose which enables potential to be accumulated. The conductor which becomes deflagrated during the short interval of time occupied by the act of discharge may oppose a resistance quite as great as that opposed by the molecules of air, the writer himself feels very sure that the deflagration of the conductor represents a much greater expenditure of energy than the breaking down the molecules of the air path, for the reason not only that there is more matter and therefore more inertia, and also because the cohesive force of the metallic molecules individually is probably greater than that of air molecules, and the number of molecules whose cohesive force has to be broken down is greater in a long metal conductor than in a short air path.

Electricity has no weight and therefore the inertia, both of air as well as metallic molecules, is necessarily infinitely greater than that of electricity and whatever may be the *modus operandi* of energy associated with a statical electrical charge, when a conductor is deflagrated an expenditure of energy at least equal to that binding the atoms of the molecules together must be necessary to separate them.

The electric current developed during the act of a Leyden jar discharge, inconceivably rapid as it is, must, like that produced by a galvanic battery, commence as a small current and rise to a maximum, then the molecules composing the air path give way, or commence to give way, when the statical charge is at its highest potential, and their breaking down is coincident with the beginning of the dynamic current developed; the resistance opposed by the air path now becomes greatly reduced as a consequence of heat produced and by far the greater part of the energy accumulated in the Leyden battery is expended in overcoming the cohesive force of the metal conductor deflagrated.

The deflagrating capabilities of Leyden batteries seem very remarkable. Mr. Crosse has told us that he could fuse into balls 30 feet of iron wire of about No. 40 B.W.C. in one length with his Leyden battery charged with 230 turns of an ordinary 20-inch frictional cylinder machine and having a surface on the one side of the jars of 73 feet. The energy accumulated in such Leyden battery must be very small compared with that which dynamos deal with; and that so small an amount of energy should be capable of breaking down a chain of molecules 30 feet long,

* It is stated at page 244 of "Elementary Lessons on Electricity and Magnetism," by Prof. Silvanus Thompson, as the result of experiments made by Messrs. De la Rue and Müller, Reiss, and Sir William Thomson, that, roughly speaking, the length of spark between two conductors increases as the difference between the potentials; and further, that Sir William Thomson's experiments confirmed the results obtained by Reiss, and indicated that the sparking length exceeds slightly the difference of potential. In the face of such authorities it may seem rash to express the opinion that the breaking down force increases as the square of the potential, but the writer feels himself justified in doing so from results obtained by him, in conjunction with his late brother, when he was a boy, more than 40 years ago. Six Leyden jars which, when charged to the potential at command, leapt an air space of about half inch, were mounted on glass tubes, and after being charged, side by side, they were suddenly arranged in series by pulling a string. According to what is stated in Silvanus Thompson's work, the discharge ought to have been capable of bridging an air space something over 3 inches, but heavy thick sparks were obtained through 16 inches of air *with certainty*, and occasionally through 18 inches, the length of the spark being influenced by the simultaneousness with which the jars were connected in series. The results obtained by the able physicists whose names have been mentioned, are due undoubtedly to the way the experiments were performed. The writer does not know the date of Sir W. Thomson's experiments, but they practically confirm some experiments made by the writer, he thinks, at an earlier date than those of Sir W. Thomson. The writer's experiments referred to, are described in the published proceedings of the Institution of Civil Engineers of 1858. In the experiments of Sir William, the discharge occurred between flat parallel plates, and they will be referred to further on in the article as supporting the writer's contention that electric currents travel theoretically faster through the centre of conductors than through their outer skins. The writer would here interpolate the remark that he feels sure that the discharge occurred in Sir W. Thomson's experiments in the neighbourhood of the centre of the plates, and here he touches the key note of his contention in respect to the passage of electric currents. He would also add, that the conditions which prevail when discharge occurs between two parallel plates are very different to those of a discharge between two balls separated by an air space or through a wire which becomes deflagrated. The experiments made through air spaces of $\frac{1}{100}$th to $\frac{1}{4}$th of an inch with De la Rue's battery of 11,000 cells, cannot be considered sufficiently reliable to establish a law. Overlooking the difficulty of perfectly insulating a battery of 11,000 cells containing liquids, the dust floating in the atmosphere through such short spaces as $\frac{1}{100}$th of an inch, would affect the results obtained. Experiments carried out by the writer a great many years ago, went to show 200 volts would establish a path through powdered blacklead of commerce which a lower voltage was incapable of effecting, and he further found a difference of potential of between 600 and 700 volts created a path for itself through more than 1 inch of the dust deposited from the atmosphere in our London rooms; that being so, it may be fairly assumed 1,000 volts would be capable of constructing a dust bridge across a space of $\frac{1}{100}$th of an inch, and 10,000 volts would do the same across a longer air space.

can only arise from the fact that its dissipation is concentrated over so small an interval of time.

Now it will be seen, the writer thinks, that a wire could not possibly be deflagrated by a Leyden battery discharge did not the wire oppose inertia, any more than a mass of wood could be penetrated by a rifle bullet were it not for the inertia which wood possesses. It is worth noting that in the example of the rifle bullet the vehicle of energy is matter which possesses inertia and consequently work is performed *in the bullet itself*, the vehicle of the energy, but in a statical charge there is an accumulation of energy unhampered with inertia and, therefore, unlike the rifle bullet, there *is no local transformation* of energy *in the* vehicle, and consequently the whole of the energy is available for doing work in the metallic wire.

The writer is disposed to think, unless he should be corrected by experiment, that when a wire is deflagrated by a Leyden battery discharge, little or no magnetism is developed, the cohesion binding together the atoms of the molecules being overcome *instead of* inertia. Magnetism he considers to result from overcoming inertia, and the overcoming inertia involves time, prolonging the act of discharge and if the inertia of the conductor is capable of delaying the rate of a Leyden battery discharge, deflagration would not occur.

All conduction is preceded by induction, the molecules of a path of discharge being subjected to more or less stress before conduction occurs. Dielectrics such as glass or gaseous matter may be regarded as being conductors whose specific resistance is so high that conduction cannot be said to fairly take place until there is sufficient energy to break down the cohesion of the dielectric structure; the deflagration of a wire by energy accumulated in a Leyden battery, it is thought, is an example of disruptive discharge, in every way resembling a discharge through a dielectric, but the expenditure of energy which the deflagration of a length of wire involves must be very much greater than that required to break down a space of air or the structure of a glass plate; in the case of the wire deflagrated, the cohesive force of a long chain of molecules has to be overcome, whereas a very small number of molecules comparatively are disrupted when an air space or a sheet of glass are broken down electrically.

It is quite true undoubtedly that a higher potential is required to break through glass, or an air space, than is necessary to break down a metallic wire, but the actual expenditure of energy is very much less for the reason that the expenditure of energy practically only commences after the breaking down has been effected and when the resistance of the path has become consequently very much reduced. In the case of a wire disrupted the resistance of the circuit increases and continues to increase up to the moment of disruption and nearly the whole of the energy of the statical charge is concerned in breaking down the molecules of the wire deflagrated.

When a statical discharge deflagrates a wire there is ocular evidence of a considerable development of heat, but when a precisely similar discharge occurs through an air path only, or a sheet of glass the evidence of heat having been produced is not so apparent. The energy accumulated, and dissipated, we may be sure, is the same in both cases, and the query is suggested, how is it that the dissipation of similar amounts of energy do not appear to give rise to similar developments of heat? It is thought the answer to such query is fairly simple, if it be only grasped that a principle of continuity connects all physical phenomena.

It has been pointed out in this, and in previous articles, that continuity can be traced between voltaic couples, plating baths, and Leyden jars, and that two platina electrodes immersed in an electrolytic liquid are to all intents and purposes a Leyden arrangement, the electrolytic liquid taking the place of the dielectric glass which divides the metallic coatings of an ordinary Leyden jar.

A Leyden jar may be considered as being not unlike a voltaic couple whose internal resistance approaches the infinitely great, at the same time it comports itself (under certain conditions) when discharge occurs as a voltaic cell whose internal resistance approaches the infinitely small; there is, however, a distinctive and important difference between a Leyden arrangement consisting of two platina electrodes immersed in an electrolytic liquid and the ordinary Leyden jar, viz., that when discharge occurs between the + and − charged platina electrodes, the electrolytic liquid which is the dielectric medium *forms part* of the circuit, and the resistance it opposes *is a very* important element in determining the rate of discharge.

In an ordinary Leyden jar the statical charge accumulated on its inner and outer surfaces is retained there by the cohesion of the glass, and also by the cohesive strength of the air molecules forming our atmosphere. Discharge may be brought about either from the energy accumulated being sufficient to overcome the cohesion of the glass, or that of the air molecules, and it may also be brought about by the introduction of a conducting path between the oppositely charged surfaces. Now, as a statical charge is prevented from discharging simply by the resistance opposed by the glass and also by that of the atmosphere, and as electricity has no inertia, the speed with which it travels at the time of discharge is determined solely by the resistance of the path; were it possible to obtain a path that opposed no resistance the discharge would be completed in an infinitely short interval of time, and that being so, we have the explanation supplied of how it is that a Leyden jar when discharging is capable of comporting itself as a voltaic couple whose internal resistance approaches the infinitely small, notwithstanding that a Leyden jar when regarded as a voltaic arrangement, as it may fairly be, resembles one whose internal resistance approaches the infinitely great.

Now, inconceivably rapid as is a statical discharge which deflagrates a wire, it occupies more time than a similar discharge through a short air space. When a wire is deflagrated the resistance opposed increases as the wire becomes heated and continues to increase up to the moment when the cohesive structure gives way to electrical pressure. It is the resistance opposed by the air path which determines the potential at the time the discharge commences, but the bursting up of the length of wire is evidence of the resistance opposed by the wire, seeing so large an amount of heat is developed in the metal path. That a wire can be burst up by a Leyden battery discharge arises, it is thought, from the current that is developed reducing the cohesive strength of the metallic structure and the resistance which it opposes becoming increased more rapidly than the potential becomes reduced, or, at all events, than the accumulated energy is being dissipated; but, nevertheless, there must have been a very considerable fall of potential before actual deflagration is effected.

Now, when a statical discharge takes place through a short air space only, the breaking down of the air molecules commences when the charge is at its highest potential, but the energy dissipated in the air path is comparatively small, because heat developed in an air path (unlike that which occurs in a metallic conductor) reduces its resistance very largely, and the greater part of the electricity accumulated in the Leyden jar, as a consequence, passes through a parth of greatly reduced resistance and therefore the discharge becomes completed in a shorter period of time. Now, as the current developed when a statical discharge occurs is greater inversely as the time in which it is effected is less, the current produced is much greater when the path of discharge consists solely of a short air space, without the addition of a length of wire, and precisely in a similar way as when the two poles of a voltaic couple are bridged by a path opposing only nominal resistance, energy becomes chiefly dissipated through the medium of heat developed in the cell, so a larger percentage of the energy accumulated as statical charge becomes dissipated in overcoming resistance to the passage of the current from the surfaces of the glass jar and through the metallic coatings.

(*To be continued.*)

ON THE EXCITEMENT OF ELECTRICITY AND HEAT IN ELECTROLYTES.

By MAX PLANCK (*Annalen der Physik in Chemie*).

(*Continued from page* 341.)

Section 2.—Complete Equations of Movement.

The accompanying equations render it possible to compute the number of the ions of each kind which, in the element of time, $d\,t$ pass through the six lateral planes of a space element, $d\,\mathrm{T} = \delta\,x\,\delta\,y\,\delta\,z$, and consequently to give the time alteration in concentration. Thus the expression (1) gives for the positive ions of the first kind which enter :

$$u\left[\Delta\,p + \frac{\varepsilon}{\mathrm{R}}\left(\frac{\delta}{\delta\,x}\left(p\,\frac{\delta\,\phi}{\delta\,x}\right) + \frac{\delta}{\delta\,y}\left(p\,\frac{\delta\,\phi}{\delta\,y}\right) + \frac{\delta}{\delta\,x}\left(p\,\frac{\delta\,\phi}{\delta\,z}\right)\right)\right]\delta\,\mathrm{T}\,.\,d\,t.$$

As $p/\mathrm{R}\,.\,d\,\mathrm{T}$ ions are present in the spacial element, the above expression gives the variation of this number in time, and we have :

$$\frac{\delta\,p}{\delta\,t} = u\,\mathrm{R}\,.\,\Delta\,p + u\,\varepsilon\,.\left[\frac{\delta}{\delta\,x}\left(p\,\frac{\delta\,\phi}{\delta\,x}\right) + \frac{\delta}{\delta\,y}\left(p\,\frac{\delta\,\phi}{\delta\,y}\right) + \frac{\delta}{\delta\,z}\left(p\,\frac{\delta\,\phi}{\delta\,z}\right)\right] \qquad (5)$$

and similar equations for the remaining positive ions. In like manner we obtain for the negative ions of the first kind the equation :

$$\frac{\delta\,\phi}{d\,t} = v\,\mathrm{R}\,\Delta\,q - v\,\varepsilon\,.\left[\frac{\delta}{\delta\,x}\left(q\,\frac{\delta\,\phi}{\delta\,x}\right) + \frac{\delta}{\delta\,y}\left(q\,\frac{\delta\,\phi}{\delta\,y}\right) + \frac{\delta}{\delta\,z}\left(q\,\frac{\delta\,\phi}{\delta\,z}\right)\right]\,.\ \&c., \qquad (6)$$

for the remaining kinds.

These differential equations, with the aid of the conditions of limits, permit the whole course of the movement to be computed if the potential function, ϕ, is known as a function of x, y, z and t. This, however, is not generally the case, but ϕ must first be determined from a special differential equation. If we denote by ρ the spacial density of the free electricity (measured electro-magnetically), then, by reason of the charges of the ions :

$$\rho = \frac{\varepsilon}{\mathrm{R}}\,.\,(p + p' + p'' + \ldots - q - q' - q'' - \ldots)$$

On the other hand we have the identity :

$$\mathrm{K}\,.\,\Delta\,\phi = 4\,\pi\,c^2\,.\,\rho, \qquad (7)$$

in which K is the constant of the dielectricity of the water, c the so-called critical speed of Clausius, consequently :

$$\mathrm{K}\,.\,\Delta\,\phi = -\,4\,\pi\,c^2\,.\,(p + p' + \ldots - q - q' - \ldots)\,.\,\frac{\varepsilon}{\mathrm{R}}$$

If we add the equations (5) for all the positive kinds of ions and from them subtract the equations (6) of the negative kinds of ions, then, by introducing $\Delta\,\phi$ on the left side we have :—

$$-\,\frac{\mathrm{K}}{4\,\pi\,c^2}\,.\,\frac{\delta\,\Delta\,\phi}{\delta\,t} = \varepsilon\,.\,\Delta\,(\mathrm{U} - \mathrm{V}) + \frac{\varepsilon^2}{\mathrm{R}}\,.\left[\frac{\delta}{\delta\,x}\left\{(\mathrm{U} + \mathrm{V})\,.\,\frac{\delta\,\phi}{\delta\,x}\right\} + \frac{\delta}{\delta\,y}\left\{(\mathrm{U} + \mathrm{V})\,.\,\frac{\delta\,\phi}{\delta\,y}\right\} + \frac{\delta}{\delta\,z}\left\{(\mathrm{U} + \mathrm{V})\,\frac{\delta\,\phi}{\delta\,z}\right\}\right] \qquad (8).$$

From this equation the change of $\Delta\,\phi$ in time can be calculated if the values of the osmotic partial pressures (therefore U and V, as well as ϕ) are given for any initial state in the entire space. By means of ϕ the movements of the single ions at any time can be calculated from the above equations. The great value of the coefficient c^2 on the left in the denominator is characteristic for the last differential equation. In consequence, $\Delta\,\phi$ and, therefore ϕ, at any given initial condition vary with extreme rapidity in comparison with the variations of the osmotic partial pressures and the concentrations, *i.e.*, all parts of the solution are almost instantly charged with free electricity. As soon as this has taken place *i.e.*, as soon as $\Delta\,\phi$ no longer varies very rapidly, in time the left side of the equation becomes approximately $= 0$, and we obtain a differential equation for ϕ in which time no longer formally occurs. The entire process, following upon any given initial condition is resolved into two distinct portions, the process of "charging" and that of diffusion properly so-called. The former requires only a very short time so that the concentrations may during its occurrence be regarded as essentially uncharged. Its end is reached when ϕ has everywhere assumed the value which appears from the subjoined equation :

$$\frac{\delta}{\delta\,x}\left[(\mathrm{U} + \mathrm{V})\,\frac{\delta\,\phi}{\delta\,x}\right] + \frac{\delta}{\delta\,y}\left[(\mathrm{U} + \mathrm{V})\,\frac{\delta\,\phi}{\delta\,y}\right] + \frac{\delta}{\delta\,z}\left[(\mathrm{U} + \mathrm{V})\,\frac{\delta\,\phi}{\delta\,z}\right] + \frac{\mathrm{R}}{\varepsilon}\,.\,\Delta\,(\mathrm{U} - \mathrm{V}) = 0. \qquad (9)$$

Then follows the diffusion, since ϕ constantly obeys this equation, and $\Delta\,\phi$ as well as the electric charges vary now more slowly according to the concentration.

Though the duration of the process of charging cannot be experimentally determined, it is of interest to obtain from theory a representation of the magnitude of this time, as it will be explained below in a simple case.

We shall be in the first place concerned with the less rapid main process, to which the last equation applies. From it we obtain by integration over any given space within the solution with the superficies $d\,\sigma$ and the internal normal ν the relation :

$$\int d\,\sigma\,.\left[(\mathrm{U} + \mathrm{V})\,\frac{\delta\,\phi}{\delta\,\nu} + \frac{\mathrm{R}}{\varepsilon}\,.\,\frac{\delta\,(\mathrm{U} - \mathrm{V})}{\delta\,\nu}\right] = 0,$$

or if we utilise equation (3) :

$$\int d\,\sigma\,.\,\mathrm{J}_\nu = 0.$$

That is, no electricity flows in or out through a closed superficies. Further, equation (7) tells us that the density ρ of the free electricity is everywhere very small, of the order $1/c^2$ (in an electrostatic measurement it would be $1/c$) so that the positive and negative ions contained in a part of space are approximately equal in number. Therefore

$$p + p' + p'' + \ldots = q + q' + q'' + \ldots \qquad (10)$$

This equation, as it is well known, forms the initial point of the researches of Nernst.

(*To be continued.*)

ELECTRIC LIGHTING AT THE UNIVERSAL EXHIBITION OF 1889.

(*Concluded from page* 346.)

Messrs. Latimer Clark, Muirhead and Co., of London, had installed, class 63, a compound dynamo capable of producing a current of 400 ampères under 85 volts, but actually producing by reason of the small number of lamps it had to supply, only 175 ampères and 85 volts. This dynamo was likewise worked by a gas motor lent by the *Compagnie Parisienne*.

Messrs. Crompton & Co., of Chelmsford, had installed three Westinghouse engines of 100 H.P each, having a speed of 300 revolutions per minute, and supplied with steam from the syndicate's station. These engines were employed to work six Crompton dynamos, two producing each 25 ampères and 220 volts at 1,200 revolutions, and four producing each 100 ampères and 220 volts per 1,000 revolutions. The total service entrusted to this firm did not exceed 180 horse, and a steam engine and two dynamos were kept in reserve.

The *Ateliers d'Œrlikon*, whose show was a very remarkable one as regards both their mechanical and electrical plant, supplied their lamps by means of a compound dynamo of 200 ampères and 65 volts, worked direct by a 50 H.P. vertical motor with a speed of 240 revolutions per minute.

MM. Alioth et Cie.'s installation consisted of a four-pole dynamo excited in series, called *Helvetia*, making 460 revolutions per minute, and furnishing a current of 8 ampères under 1,500 volts. This dynamo was worked by a vertical compound steam engine of Sulzar-frères' construction, and had a speed of 250 revolutions per minute.

Like the preceding one, this installation was very complete in every respect, and was much noticed by competent judges.

Installations de l'Esplanade des Invalides.—When we opened negociations with the administration the lighting of the Esplanade des Invalides formed no part of our scheme; but at the very urgent solicitations of the commissioners of the Algerian and Tunisian colonies we agreed to undertake the partial illumination of this vast site.

This portion of the lighting was supplied by:—

1. A station established by the *Compagnie Électrique* close to the Javanese *Kampong*.
2. A station established by M. Garnot in front of the *Pavillon des Postes et Telegraphes*.
3. A locomotive placed upon the Seine embankment by the *Société l'Eclairage Electrique*.
4. A dynamo worked by a steam engine installed in the pavilion of Messrs. Geneste et Herscher.
5. Lastly, by a current from the central station of the *Société l'Eclairage Electrique* in the Champ de Mars.

These electrical stations comprised 2 boilers, 4 steam engines, 3 gas motors, and 9 dynamos, total power of which was 250 H.P.

The syndicate possessed, therefore, in mechanical and electrical plant, for the lighting of the Champ de Mars, the Quai d'Orsay and the Esplanade:—30 steam boilers, 31 steam engine, 14 gas motors, 96 dynamos, and 370 accumulators, the total normal power of which slightly overstepped 4,000 H.P.

I gave you in March last, the distribution of the lamps required by the administration and told you that the syndicate contemplated installing 1,000 arcs and 10,000 incandescent lamps.

Actually the syndicate installed:—

1. For the public service,	1,093 arcs	and	8,839	incandescent lamps.
2. For private consumption,	406 „		3,816	„ „
Total	1,499 „		12,655	„ „

It remains for me to examine with you the results of the syndicate's work from the point of view of luminous intensity and regular lighting in the various sites open to the public after nightfall.

First of all let us take the *Palais des Machines* as it was some months ago.

The lighting is complete, and apart from some arcs, whose lights vacillate slightly, the lamps are working with remarkable steadiness.

The entire length of the central longitudinal avenue is brilliantly illuminated; the higher lustres have a very fine effect; the aspect of the entire enclosure, the pillars and roof of which are clearly distinguishable, is altogether satisfactory.

Both the two longitudinal gangways nearest the central one are furnished with 20 regulators of 25 ampères, they are less brilliant than the central avenue but are nevertheless, completely lighted, and the details of the exhibits arranged to the right and left are plainly discernible by visitors.

The same remark applies to the next two passages.

The two passages which run along the pillars bordering upon one side the nave and upon the other the two aisles, only receive light from the large central furnaces (*foyers*), the arcs in the aisles and the 25 ampère arcs placed above the other passages.

The lighting, which is adequate and even abundant in those parts of the Exhibition devoted solely to machinery, is, in my opinion, too feeble in the neighbourhood of the large factory installations—that is to say, distilleries, paper factories, &c.

The transversal walks are all well lighted. The aisles and the first story, furnished with several hundreds of eight ampères regulators, are abundantly provided for.

The general impression is this: if, commencing our visit at the furthest longitudinal passages, we walk through the Palais so as to conclude our visit in the central avenue, we are struck with what appears to be the perfection of lighting; if, on the other hand, we start at the central avenue and finish in the passages alongside the pillars, our impression is that the lighting is imperfect. To remedy this, and to make the lighting more uniform, all that would be necessary is to set up 40 lamps in the furthest passages and to lessen the intensity of the large lustres. Nothing was more easy than to have only lighted a certain number of arcs in each large lustre; this has been done in ordinary circumstances, but it was practically impossible for the syndicate to make installations in the Palais after the defect was perceived.

When the lighting of the *Palais des Machines* was planned by us we were in absolute ignorance of the fact that regular enclosed structures and entire factories several stories high would be placed in the nave, or we should have made arrangements accordingly.

There was another subject for criticism: those electricians who did not belong to the syndicate were free in the evening to light up their exhibits on their own account. Several made an abuse of this privilege; the American section, class 62, and the exhibit of the Société Alsacienne were literally overpowering in this respect, so that by comparison everything else appeared badly lighted.

The syndicate might have obtained administrative interference to moderate the brilliancy of this supplementary lighting; but we preferred not to complain and to suffer a trifling annoyance rather than give offence to our *confrères*.

The total luminous intensity shed upon the ground occupied by the *Palais des Machines* was largely in excess of that demanded by the State; but sensibly less than was calculated for by M. Brault, our engineer. This inferiority was due to several causes; in the first place, M. Brault's calculations were based upon former experiments, which he was obliged to repeat with the aid of improved ampèremeters; next, the carbons of the majority of the regulators were somewhat too large for the currents intensities, which, as you are aware, has the effect of lessening the light produced; lastly, the globes were, generally speaking, too opaque, and shed less light upon the ground than would have been the case had the globes we contemplated been used.

Apart from these trifling imperfections, the lighting of the *Palais des Machines* may be said to have been very satisfactory.

The *Court de la force Motrice* and the *Courts Suffren* and *Labourdonnais* were provided with excellent lighting.

The 30 m. gallery with its 42 Cance lamps, had a lighting which was regular, steady, and sufficiently intense. The exhibitors may, possibly, have wished for a little more light; but if the lighting was somewhat feeble for judging the details of an exhibition by, the fault was not of the syndicate's, who had never contemplated the presence of exhibitors on this site.

The central dome was as remarkable in the evening as in the daytime, which is saying not a little. The numerous arc lamps threw into relief the beautiful architectural lines of the interior, whilst the lustres and the larger corona, composed of powerful incandescent lamps at white heat merely, conserved to the fine interior paintings all their decorative qualities. This was certainly one of the most successful portions of our programme. Personally, I deem it a matter of congratulation that we resisted the architects' demands for arc lustres in the interior. Instead of a soft, faintly golden-tinted light, we should have had one of a bluish, almost lunar hue, which would have been exceedingly

detrimental to the paintings instead of enhancing their merits.

The garden pathways were provided with arc lamps at short distances.

The kiosks were lighted, and well lighted, by incandescent lamps in series groups of four or six, surmounted by small, almost flat-shaped reflectors.

The lawns were encircled by cordons of incandescent lamps of slight intensity, in globes of white or coloured glass. M. Alphand was greatly attached to these luminous cordons. I confess to a less appreciation of their charm, and had the syndicate been allowed its own way, the lighting of the lawns would have been carried out differently.

The luminous English fountain left nothing to be desired; the public was so delighted with the spectacle that the rain even could not compel it to leave the garden whilst the performances lasted. It played three times every evening during the exhibition, except on one occasion out of the 184, when, owing to mismanagement at the station, there were only two performances.

M. Bechmann's fountains were likewise greatly admired; their playing was only interrupted once, owing to absence of current, and on three occasions subsequently from failure of water.

The public lighting of the *Esplanade des Invalides* was somewhat disappointing, because the colonies would only spend what was strictly necessary. So, in spite of the liberality of the syndicate in lighting the approaches to the principal entrance and the whole of the kiosks for nothing, many portions of this vast site remained in almost complete obscurity. The promoters, it must be said, blundered in this; the public went every evening to see the *Palais des Machines* and the luminous fountains, and completely ignored the *Palais Coloniaux*.

To sum up, the electric lighting of the Universal Exhibition taken in its entirety and without prejudice was excellent. Impartial statements which cannot fail to be made in high quarters will say that the syndicate has performed with honour the mission which was confided to it, and that it has contributed in no slight degree to the colossal success of the Exhibition.

It only remains for me to express the wish that all parts of future exhibitions may without any exception be open to visitors in the evening, and that electricians and electricity may be paid for in the same way exactly as gas. My mind is tranquil as regards the future: M. Georges Berger, our honorary president, who is now deputy, may become minister; in which case he will not fail to completely satisfy the just claims of electricians.

The PRESIDENT said: We have all admired the success which has been attained by the syndicate of this enterprise; it was a bold undertaking, and attempted under conditions of peculiar difficulty. You must have been gratified, as I was, at being reminded by a voice so well authorised to speak on the subject, of the wonderful things which made so lively an impression upon the innumerable visitors to the Exhibition. I am sure I am only giving utterance to your feelings in thanking M. Fontaine for having so well kept the promise he made before the exhibition opened; and I believe you will associate yourselves with me in the congratulations which I feel bound to offer through him to the members of the syndicate for their patriotic endeavours which have contributed so greatly to the brilliant success of our great Exhibtion.

M. DE NERVILLE said: At the request of the jury of awards in Class 62, I undertook a course of experiments for calculating the exact amount of lighting of the various portions of the Exhibition. I was assisted in this by M. Lepage, a pupil at the *Laboratoire Central d'Eléctricité*. M. Dierman likewise gave his assistance.

The measuring apparatus employed was a Mascart photometer, the same which was made the subject of a communication to the *Société Internationale des Electriciens* in 1888, and which, therefore, it is not necessary to describe.

Particular care had been taken to increase its exactness; the screen was formed of a sheet of thick white paper. The amount of light emitted by the second face of this screen for divers incidences was found to be very perceptibly proportional to the cosine of the angle of incidence.

The light lost through reflection may therefore be considered as *nil*, and the photometer's indications are practically proportional to the quantity of effective light diffused by a sheet of paper situated at the point regarded.

The source of light which served for comparison was a small sized moderator oil lamp, the wick and the glass of which were always regulated under the same conditions by the same operator. A square diaphragm, situated in front of the flame, marked out a well-defined luminous surface, and experiments made at the *Laboratoire Central d'Eléctricité* justified the presumption that the light emitted across this diaphragm underwent only trifling changes, even when the amount of oil consumed varied considerably. The light from this lamp traversed a sheet of paper precisely similar to that forming the screen, so that the eye had to compare two lights of similar nature.

Owing to the impossibility of estimating the equality of two illuminations of different tints no experiments have yet been made with white lights. The photometer eye-piece was furnished with a red and a green glass of tints similar to those used for railway signals, and each measurement was successively made by looking through each of these glasses. The reading from the green and that from the red were set down and the desired conclusion drawn from them relatively to the actual lighting. Apparently the amount of effective light is not proportional to the mean of the two indications, but should approximate much more to the relative value of the green glass.

The photometer was gauged for both colours: a carcel lamp standard, consuming 42 gr. oil per hour was situated at 1 m. from the vertical screen, and the readings with the photometer corresponds to the red and green rays overstepped the constant of the apparatus. This constant had to be calculated by each of the two experimenters. The personal error was found to be considerable, and to betray great dissimilarity in the experimenters' methods of estimating the equality of the illumination of two neighbouring surfaces. But this personal error is very consistent, and apparently has but slight influence upon the final results.

Under such conditions, then, the intensities of the illuminations are estimated, both as regards the red and the green, in fractions of the quantity of light of similar colour shed ordinarily upon the screen by a carcel lamp situated 1 m. away.

The following table sums up the results of the miscalculations in some forty different points. According to the case, the screen was horizontal, vertical, or inclined. Its height above the ground was invariably 1 m. 40.

It will be observed that in almost every case the numbers corresponding to the green glass are larger than those relative to the red one; which would mean that the radiation received by the screen contained a corresponding amount of green rays, greater than the light of a *carcel*. Those points which are exceptions to this rule are all found in regions lighted by incandescent lamps of low pressure whose light is calculated to show the red or yellow decorations of a wall to advantage. Such were those of the central dome and the adjoining staircase, the portions of exterior galleries lighted from a ceiling studded with Edison lamps, and the garden kiosks. Everywhere else arc lighting prevailed, and the ratio of the green illumination to the red ditto was so much the greater as the screen received the light more directly from the arcs. This ratio varied from the minimum 1·4 at the extremity of the *Galerie des Machines*, a region partially lit by incandescent lamps and receiv-

ing a large proportion of the light reflected by the Palais walls, to the maximum 2·7 in one of the galeries of the *Palais des Beaux-Arts*, at a short distance from the great regulator. In the *Palais des Machines*, the *Galerie Rapp* and the *Galerie Desaix* this ratio was maintained at close upon 2.

With the exception of a small number of points removed from every powerful luminous source, and receiving rays very obliquely, the photometric intensity upon a horizontal plane was much less considerable than that striking a vertical plane. It will be observed that in a similar region, such as the *Palais des Machines* or one of the other large galleries, the illumination upon a horizontal plane varied within considerable limits according to the position with regard to the lamps. On the other hand, the illumination of a vertical plane was remarkably uniform at every point, and in the various directions around the same point.

The greatest luminous intensities were found at certain points of the *Palais des Machines* (strong lighting 4 and 5·2), in the aisles of the same (5·3), in the Galerie Desaix (4·4 and 7·3), in the Galerie Rapp (3·7), and upon the terrace of the Rapp entrance, where the horizontal green illumination reached close upon 10 carcels.

PALAIS DES MACHINES.

	Direction of the screen.	Ordinary lighting. Red glass.	Ordinary lighting. Green ditto.	Strong lighting. Red glass.	Strong lighting. Green ditto.
	CENTRAL AVENUE.				
1	Horizontal	0·7	1·1	...	...
	Vertical south	0·6	(0·9)	...	...
2	Horizontal	0·5	1·0	0·6	1·6
3	Vertical north	...	...	...	...
4	Horizontal	1·0	2·3	...	...
	Vertical south	0·6	1·4	...	...
	Vertical north	0·7	1·3	...	...
5	Horizontal	...	...	1·8	4·0
6	Horizontal	1·8	2·9	...	...
	Vertical north	1·1	1·7	...	...
	Vertical south	0·8	1·7	...	...
7	Horizontal	0·6	1·4	1·0	2·3
	Vertical south	0·7	1·4	1·4	3·1
	At 45° towards a lustre...	...	...	1·7	4·0
8	Horizontal	0·7	1·5	2·1	5·2
	Vertical south	0·5	1·2	1·2	3·0
9	Horizontal	1·6	2·3	...	...
	Vertical south	0·5	0·9	...	...
	Vertical east	1·3	1·9	...	...
	2.—LATERAL AVENUES.				
10	Horizontal	...	...	1·1	2·6
	Vertical north	...	...	1·0	1·8
11	Horizontal	1·3	2·4	...	...
	Vertical north	0·7	1·5	...	...
	Vertical south	0·6	1·2	...	...
12	Horizontal	...	...	1·3	2·3
13	Horizontal	...	...	0·7	1·2
14	Vertical west	...	...	0·6	2·0
	A 45° towards a lustre...	...	...	0·8	1·7
	3.—SIDES OF PALAIS UNDER THE SURROUNDING BALCONY.				
15	Horizontal	3·4	5·3	...	...
16	Horizontal	1·7	3·8	...	...
17	Horizontal	1·2	2·2	...	...
	Vertical north	0·5	1·0	...	...
18	Horizontal	2·7	5·5	...	...
	Vertical south	1·6	3·7	...	...

Note.—The two left-hand columns correspond to the ordinary lighting; the right-hand ones to the lighting on *fête* days, differing from the former by the complete illumination of the four great lustres. Points 1, 2, 3 are each under the great lustres—four at equal distances between two great lustres—5, 6, 7, 8 at unequal distances from each of the two neighbouring great lustres—9 at the extremity of the Palais (Labordonnais entrance) under the clock—10, 11 first lateral avenue leading away from the principal avenue—12, second lateral avenue—13, third avenue along the abutments of the girders—14 on the surrounding balcony at the end of the little axis of the *Palais des Machines* (near the School Military), facing the interior of the Palais—15, at the foot of the staircase, behind the Bréguet exhibit—16 and 17 in the Annexe des Chemins de Fer—18 in the Belgian section.

	Direction of Screen.	Red Glass.	Green Glass.
	LESSER DOME.		
19	Towards the centre — Horizontal ... ... Galerie de 30 m.	0·2	0·3
20	On the axis ... Horizontal	0·9	1·4
21	In the passage ... Vertical, west ...	0·5	1·0
22	In the passage ... Horizontal	0·6	0·65
	CENTRAL DOME.		
23	In the centre ... Horizontal	0·6	0·5
	In the centre ... Vertical (towards gallery)	0·3	0·4
24	Laterally ... ... Horizontal	0·5	0·4
25	First story (balcony) Horizontal	1·6	1·3
	First story (balcony) Vertical (towards interior)	0·7	0·5
26	First story „ Vertical (towards gallery)	0·7	1·3
27	Gobelin's staircase Horizontal	1·6	1·3
	EXTERIOR GALLERIES.		
28	Gobelin's staircase Horizontal	0·5	1·3
29	„ „ „	0·6	1·4
30	„ „ Horizontal	1·7	2·9
	„ „ Vertical, west ...	0·3	0·5
31	„ „ Horizontal	0·7	1·9
32	„ „ „	1·0	0·9
	SUFFREN GALLERY.		
33	Under the 1st lustre, Palais side ... Horizontal	1·8	4·4
	Under the 1st lustre, Palais side ... Vertical, north ...	0·7	1·4
	„ south ...	0·4	0·9
34	Under 2nd lustre... Horizontal	4·2	7·3
	Under 2nd lustre... Vertical, south ...	0·8	1·7
	„ south-east ...	0·8	1·5
	RAPP GALLERY.		
35	Under lustre ... Horizontal	1·8	3·7
	Under lustre ... Vertical	0·7	1·3
36	Near to lustre ... Horizontal	1·0	2·0
37	Between two lustres Horizontal	0·3	0·6
	Between two lustres Vertical	0·7	1·3
38	Close to Porte Rapp Vertical (towards gallery)...	1·2	2·1
	TERRACE, RAPP ENTRANCE.		
39	At centre of steps — Horizontal	4·9	9·9
	UNDER A GARDEN KIOSK.		
40	Under a lustre ... Horizontal	1·4	1·0
41	Between two lustres Horizontal	0·4	0·6
	Between two lustres Vertical	0·4	0·4

Note.—Point 25, upon the balcony of the central dome, before the Gobelins exhibits; 26, upon the portion of same balcony, forming bridge over the Galerie de 30 m.; 28, before the Restaurant Française; 29, before the Brasserie Suisse; 30, 31, before the Restaurant Ducastoing; 32, before the Restaurant Sapin, portion of the gallery lighted from a ceiling studded with incandescent lamps.

This concluded the sitting.

A SYNTHETIC STUDY OF DYNAMO MACHINES.

(*Continued from page* 174.)

VIII.—ARMATURE REACTIONS.

So far we have considered the magnitude of the E.M.F. produced in a rotating armature, but without introducing considerations respecting the effect produced on the field when a current flows in the armature winding. We have shown how the magnetising force necessary to produce a given induction in the armature core can be calculated, but we have to estimate now what modification, if any, our calculation requires due to the effect on this field of the armature, which itself becomes a magnet when a current flows round it.

We have seen that in a two-pole machine the E.M.F. is induced in the same direction in all the conductors extending over one half of the armature, while in all those extending over the other half it is induced in the

opposite direction. In all the conductors on one side of a diametrical line joining the brush points the current flows in one direction, while in all those on the other side of the line it flows in the opposite direction. This may be shown in fig. 144, where C is an armature core and A and B show the position of the brushes, the current in the conductors flowing into and

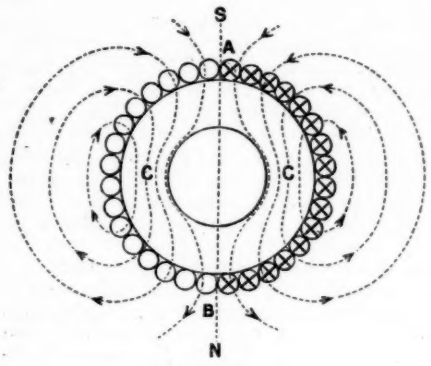


FIG. 144.

out of the paper, as indicated by the open and crossed circles respectively. The armature core is by these currents converted into an electro-magnet, there being produced in consequence a field the direction of which is indicated by the dotted lines, with N and S poles where lettered. Part of the field passes across the interior opening, but this is not shown in the fig. Since half the total current flows through each conductor, the magnetising force in ampère-turns is obviously the product of half the conductors counted all round the armature, and half the current, or one-fourth of the current multiplied by the conductors. The lines of force have to complete their circuits through a very large air gap here, and the field may be comparatively weak, but if masses of iron are placed in proximity to the armature so that the lines can complete their path through iron instead of air; in other words, if the armature is placed between the massive pole pieces of a magnet the field produced is very strong, the lines of force closing through the pole pieces, E F., as in

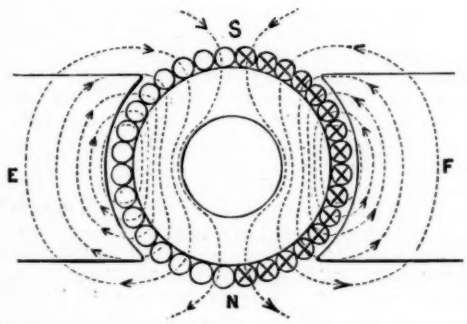


FIG. 145.

fig. 145. We have thus a cross field induced by the current in the armature, and the effect of this second field which is superposed upon the original forward field must be taken into account in designing the machine. If there were no current round the armature the lines of force due to the field magnets would be arranged symmetrically on each side of a vertical diameter, as in fig. 146, but when the current flows in the armature coils, this symmetry is disturbed the resultant field to the forward and cross induction combined being then as sketched in fig. 147. It will be seen that where the cross induction opposes the forward induction the field is weakened, but where it helps the forward induction the field is strengthened. Resulting from this the lines are crowded together at the top right hand and bottom left hand corners of the poles as shown. When the currents flow round the field magnets and armature in the relative directions sketched the rotation of the machine will be as shown

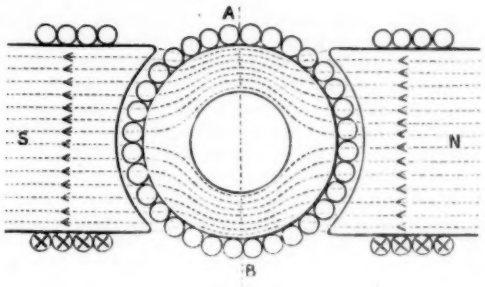


FIG. 146.

by the arrow, and accordingly the neutral point at which the induction is reversed, is moved forward in the direction of rotation. If the brushes were allowed to rest at A and B, a certain amount of sparking would result from the shifting round of the field having rendered the sections under the brushes active. But in successful working it is essential that sparking be

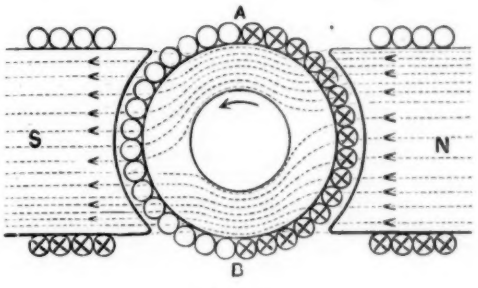


FIG. 147.

absent, so the brushes must be moved through a certain angle in the direction of rotation, or in other words, given a lead in order that the sections when short-circuited may be in an almost neutral field.

A lead being given to the brushes by placing them at A and B, fig. 148, it will be observed that the convolu-

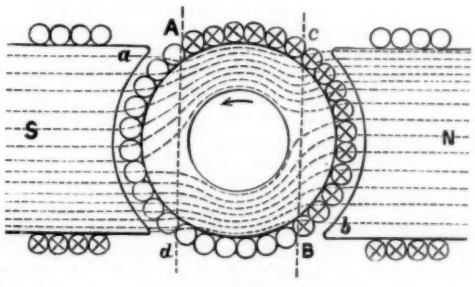


FIG. 148.

tions lying between the two vertical lines, A, *d* and *c*, B, directly oppose the forward induction, as they constitute a number of belt enclosing the field in which the current flows in an opposite direction to

the current round the magnets. Under these circumstances the effect of the current in the armature may be best considered by imagining the conductors divided into two portions wound at right angles, the convolutions between the lines, A, *d* and *c*, B, constituting one portion, directly weakening the field, or reducing the forward induction, while the other portion constituted by the remaining conductors tends to produce a cross induction, and so distort the field, as already described. The number of ampère-turns weakening the field is obviously the product of the number of conductors between A, *c* or *d*, B, and half the armature current, while the ampère-turns producing the cross induction are the number of conductors to the right of B, *c* or to the left of A, *d*, multiplied by half the armature current. Mr. Swinburne, to whom the above manner of considering this question is due, has developed the idea in quite a remarkable way in a paper recently read before the Institution of Electrical Engineers. It is in his paper assumed that the proper position for the brushes is just under the polar corners at *a* and *b* (fig. 148), and this being so, that the weakening effect of the armatures on the field can always be foretold before the machine is constructed. According to this assumption, about the truth of which there appears to be some doubt, however, all the conductors lying in the gap, between the polar tips, belong to the component of the armature which produces the weakening effect, while all those lying under the pole-pieces belong to the component producing the cross induction. But whether the brushes are right under the corners or some distance behind them, as is more frequently the case, it is evident that the cross induction must not be great enough to reverse the direction of the field through the sections under the brushes, or such sparking will ensue as to make the machine unworkable.

When a section is short-circuited under the brush the current flowing in it is stopped, and a current has to flow in it in the reverse direction when the short-circuit is removed. The armature, when the current flows in it, is, as we have seen, a magnet, and as it rotates there are due to the constant short-circuiting of the sections slight periodic variations produced in its field. The armature field results from the added effects of the currents in all the sections, and as they pass the brushes the strength of this field is diminished a little, due to the stoppage of the current in those short-circuited. Any lines of force which were induced due to the current flowing in the section are annihilated when it is short-circuited, the current tending by self-induction to continue in the same direction. If the short circuiting took place in a perfectly neutral field an abnormally large current might be set up in the section due to self-induction; at the same time it would leave the brush without the current in the opposite direction having been started in it. On this account it is necessary to work with the brushes slightly in advance of the position of neutral field; when it passes under the brush there must, in fact, be a forward induction of such strength through the section that the current shall be stopped, reversed and brought up to its normal value in the opposite direction before the short-circuit is removed. This explains why it is impossible to work the machine if the cross-induction is so great as to reverse the direction of the field through the sections under the brushes.

(*To be continued.*)

Frankfort Electrical Exhibition.—This exhibition, our readers will remember, was to have been held this year, but has been postponed until 1891. A new prospectus has now been issued, giving the classification, which is as follows:—(1) Motors (steam, water, air or gas) for electrical purposes; (2) Generation of electricity; (3) Conductors; (4) Accumulators; (5) Electric transmission of power; (6) Electric lighting; (7) Telegraphy and telephony; (8) Electric signals; (9) Electro-metallurgy and electrolysis; (10) Instruments; (11) Medical electricity; and (12) Literature.

THE DEPTFORD STATION AND THE SOUTHWARK ELECTRIC RAILWAY.

WHEN will the Deptford station be started? Information regarding this huge undertaking seems to be withheld precisely in the same manner as in the case of the City of London Electric Railway. When two of our friends endeavoured to obtain information concerning the latter, especially with a view to taking part in a trial trip, they were shown old newspaper cuttings, and were informed that the electric locomotives had for the present, and for over two months to come, ceased running, possibly until the line is opened for traffic. We believe, however, that the locomotives continue to make experimental trips; and the only conclusion to be drawn from this is that the company is afraid of an adverse criticism. The company proposes, although details have not yet been settled, to make a uniform charge of twopence for the journey from London Bridge to the Stockwall terminus and *vice versâ*, and this price will probably be the same when the extension to Clapham Common is carried out. Railway *employés* at the stations will be almost, if not entirely, dispensed with. The reason for this is that turnstiles will be provided at each station, and the fares will be placed by passengers in suitable boxes. But what will prevent anyone from passing through a turnstile without paying his fare? Doubtless an arrangement will be provided by which the turnstile will be automatically locked until the amount of the fare has been deposited in a slot, and the act of dropping in the money will automatically free the turnstile to allow one person to pass, when the turnstile will be again automatically locked. Here, then, is a chance for an automatic turnstile maker; but what about the question of obtaining change? We would suggest the placing in each station of an automatic dummy with his pockets full of small packets of money in change, in a similar manner to that on the one-horse 'buses of the London General Omnibus Company, although, in the latter case, the change-giver is alive. In such a case, it might be possible for a benevolently-inclined individual to defraud the dummy by placing in the change-slots a counterfeit coin, or a piece of worthless metal of the same weight and size of a sixpence or shilling—a sure fortune for an ingenious person, whom it would be difficult to detect. Possibly, after all, it would be best for the company to pay a man a fair salary to give change, and so prevent fraud.

The Deptford station was announced to be in operation some six months ago, but this was probably a mistake in a figure—perhaps November, 1899, and not November, 1888, was the date intended for the inauguration. What with the difficulties encountered with the "small" 1,500 H.P. dynamos, the breaking down of the Ferranti and Fowler-Waring cables, and the induction in the telegraph wires from the high tension cables on trial, the lot of the London Electric Supply Corporation has not been a happy one. It is even reported that the aid of Messrs. Siemens has been called in to assist in overcoming the almost insurmountable difficulties. Why does the London Electric Supply Corporation keep everybody in the dark? Far better would it be for them to make an official statement showing the exact condition of the Deptford station, rather than let people draw their own inferences, and say the most unkind things about it. At present the Corporation flatly refuse to give any information concerning their station, and Messrs. Ferranti and Sparkes also decline to do so. Nevertheless, *when* the blissful day of successful working arrives, all unkind sayings about the station will be forgotten.

An Easter Egg.—Why are the Ferranti cables reported to have been unable to withstand the 10,000 volts pressure? Because there is something wrong with the *Ince-ulation*.

THE FAWCETT GAS ENGINE.

Two important points are at present being considered in gas and other engines. One is extreme simplicity, and the other that the engine should have as few moving parts as possible. The latter plan is partly adopted for the purpose of reducing the liability of the engine getting out of order, because gas engines are often placed in charge of inexperienced persons. The Fawcett gas engine, which was exhibited at the recent Agricultural Hall Exhibition, appears to fulfil these two conditions. In this engine, the whole of the motion work comprises a slide valve and exhaust valve, these being actuated by a single eccentric, as in an ordinary steam engine. Thus the usual geared wheels, side shaft, cams, and clack valves are entirely dispensed with. In the cycle of operation, the piston of the compression cylinder on its outward stroke draws a charge of gas and air, and on its return stroke it forces the mixed gases into the power cylinder. Simultaneously, half of the waste gases are driven out, and the returning piston of the power cylinder forces out the other half. These operations take place during about half of the in-stroke of the power cylinder piston, when the exhaust is closed, whilst the compression of the gases is completed during the remaining in-stroke of the two pistons. The charge is then fired, and the power imparted to the crank shaft in the ordinary manner. Thus one explosion takes place at each revolution of the engine, and the force of the explosion, and the quantity of gas used, are proportioned to the load on the engine by an ingenious arrangement of the governor.

The running of the engine is exceedingly steady, owing to the disposition of the governor, this being an important point in the operating of electric light and other machinery, where steadiness in driving is absolutely essential.

A test was recently made with a 6 H.P. (nominal) engine, showing it to be very economical in the consumption of gas, and to have a high mechanical efficiency. The data are as follow :—Motor cylinder, 8 in. diameter by 15$\frac{15}{16}$ in. stroke; compression cylinder, 6$\frac{1}{2}$ in. diameter by 15$\frac{15}{16}$ in. stroke; total gas used, 210·8 cubic feet per hour; revolutions, 150·8 per minute; indicated horse-power, 11·49; brake horse-power, 8 52; gas used per indicated horse-power (mean only), 18 4 cubic feet; gas per brake horse-power per hour (mean only), 24·74 cubic feet; mechanical efficiency, ·741.

A NEW SYSTEM OF ELECTRIC ACCUMULATORS AND ITS ACCESSORY APPARATUS.

In a note by M. Charles Pollak (*Comptes Rendus*) he says: My experiments with accumulators of the Planté type were chiefly with a view to securing great capacity in the shortest possible space of time. To this end I covered the plates with spongy lead obtained by electrolysis. To secure the perfect cohesion of the lead and the plated surface the latter was treated in such a way as to present the appearance of a smooth-haired brush, this being obtained by means of a special laminating roller. The points were 2 mm. in height and 1 mm. at the base, the interstices between the points being 1 mm. The plate having been washed in order to be free from grease was coated over with a paste composed of sulphate of lead tempered in brine, and was then immersed in brine between two sheets of zinc.

The appearance of the reduced plates was uniformly grey, the adhesion of the spongy lead to the plated surface and to the points was perfect.

These having been properly soldered, next we proceed to the formation of accumulators, this being done by causing the current to pass in one direction during a space of 50 hours. The negatives assume a greyish aspect, and the positive ones are a decided brown. After the formation the adhesion of the active material (spongy lead and bioxide of lead) is so perfect that it is impossible to distinguish the place where the overlaying stratum commences.

An accumulator composed of nine plates, four positive and five negative, having a total weight, including the connecting rods, of 11·206 kg., gave, after 24 hours formation with a current of 16 ampères, during the discharge :—

Hours.	Ampères.	Volts.
Mid-day	18	2·12
1	,,	2·08
2	,,	2
3	,,	2
4	,,	2
5	,,	1·9
5·18	,,	1·8

Total: 95·4 effective ampère-hours.

The resistances over which the discharge was made were regulated so that the discharge should be of equal intensity throughout. The same accumulator, being recharged with a current of 16 ampères for a space of seven hours, gave during the discharge the following :—

Hours.	Ampères.	Volts.
Mid-day.	17	2·2
1	17	2
2	17	2
3	17	2
4	17	2
5	17	1·95
5·30	16 5	1·92
5·45	16·4	1·87
6·4	16	1·8

Total: 102·35 effective ampère-hours.

A yield, therefore, of 91·384 ampères per cent.

The capacity is 9·133 effective ampère-hours per 1 kg. of lead.

Further, it will be seen by the two tables above that the accumulator's E.M.F. altered but very slightly during the discharge, but fell suddenly at the close.

I endeavoured to get with a small volume and slight weight a high tension current for adaptation in particular to the requirements of portable lighting. For this purpose I have constructed a small battery of accumulators, which I have called *accumulateur multiple*. It is composed of plates, each having a positive and a negative side, and rubber envelopes separated by frames in ebonite. The whole is perfectly staunch.

POLECHKO'S DISC DYNAMO.

The following details relative to this new machine were, says M. A. Besson in *La Lumière Electrique*, given by the inventor at the eighth Congress of Russian Naturalists.

The inventor's object appears to have been the creation of an industrial type of the Barlow wheel which should be simpler than those of Sir William Thomson and M. Ferranti, though of similar class. Exteriorily it presents a disc formed of a kind of flat pulley in a single piece of great diameter, and very thin.

The disc forming part of the Polechko's machine is made out of a single piece of metal, one metre in diameter; it is insulated from its axis and divided radially into 350 sections, separated from each other by some fibrous insulation to a distance of 13 centimetres from the axle. The periphery of the disc is bordered by a hoop of steel and insulated from the disc; it is wider at parts of the hoop so as to serve as a

collector ; the brushes are situated at the extremities of an equal diameter and of the diametrically contrary magnetic points of electro field magnets. With such a disc, as with that of Faraday, the amount of E.M.F. which may be usefully induced in the length of a diameter is calculated thus :—

Let a represent in centimetres the radius of the disc, and a' that of the entire central portion, the length of the induced conductor in each radial magnetic field is :

$$l = a' - a ;$$

the number of revs. per second made by the machine being n, the mean linear velocity of each radial portion of the disc subjected to induction is

$$v = 2\pi \frac{a' + a}{2} n.$$

Let H represent the intensity of the magnetic field in C.G.S. units (number of lines of force).

The E.M.F. induced in each radial portion is expressed in volts by

$$e = \frac{n \, H \, v \, l}{10^8} = \frac{n \, H}{10^8} \pi \, (a' + a) \, (a' - a) = \frac{n \, H}{10^8} \pi \, (a'^2 - a^2).$$

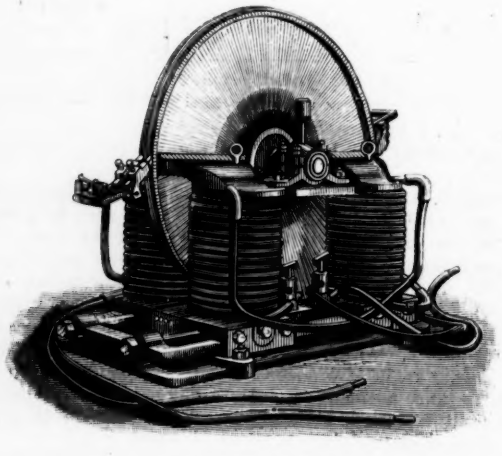
This E induced in both effective radial portions is double :

$$E = \frac{2 \, n \, H \, v \, l}{10^8} = \frac{2 \, n \, H}{10^8} \pi \, (a' \, 2 - a^2).$$

Therefore

$$E = \frac{2 \, n \, H}{10^8} S$$

bearing in mind that $S = \pi \, (a' \, 2 \, a^2)$ is the active surface of the disc.



Under these conditions with the dimensions shown by the machine (which are those of the first constructed by M. Polechko) we find that with a velocity of 27 revs. the second (about 1,600 per minute) the disc dynamo is capable of developing 50 volts, subject to the magnetic field's intensity, H, equalling 12,600 C.G.S. units.

In many well known dynamos the magnetic intensity of the cores reaches 7 and 10 thousand units ; but in all machines alike the magnetic intensities of these cores become rarified in the *entrefer*, by reason of the development of the polar pieces, and the magnetic flow, properly speaking, is only two to three thousand units. This development of the polar pieces is not obligatory, and it is possible to have the intensity of the field in the *entrefer* not merely equal but surpassing even that of the cores.

The intensity of the magnetic field is easily obtained by establishing it upon the data determined by Kapp and by Shelford Bidwell.

Thus we establish by means of the above calculation that a rationally constructed disc dynamo is capable of furnishing an E.M.F. sufficient for all practical applications.

In the first machine constructed by M. Polechko, the magnetic intensity of the *entrefer* was only equivalent to that of the cores, viz., 6,500 units.

This machine gave 25 volts and 2,000 ampères when running at 1,500 revolutions per minute ; its weight was 1,140 kilos.

M. Polechko is engaged upon the construction of a new pattern of his machine which will be almost of similar dimensions, but will be furnished with a metal more suitable for the magnetic circuit. There is reason to hope that dynamos such as these, of solid construction, trifling weight and great simplicity, will be found applicable in electrolysis, electro-metallurgy and even electric lighting.

NOTES.

Electric Lighting and Paddington Vestry.—At a special meeting, called to consider the report of the Lighting Committee, Colonel H. C. Barchard observed that since the report had been drawn up the Metropolitan Company had varied its list of prices, and probably the other company would desire to vary its scale of prices, and he should propose that the company be communicated with for that purpose. Colonel Blair objected to this intervention, and was in favour of the recommendation of the committee being adopted as passed by them. Mr. Stephenson seconded Colonel Barchard's proposition ; and Mr. Mills moved, as an amendment : "That the provisional order prepared by the committee and recommended to the support of the vestry does not secure to the ratepayers such advantages as they are entitled to receive as a consideration for the very valuable concession involved in the vestry granting its assistance to a company to obtain an order for lighting the parish of Paddington." Mr. Anderson seconded the amendment. Mr. Mark Judge opposed the report as not being a trustworthy document, and moved that the matter be adjourned for further consideration. After a lengthy discussion this was agreed to.

A First Installation.—The electric light was displayed in Farnham for the first time a few days since at Mr. G. Elliott's Reliance works, West Street. The generating machinery was driven by a paraffin oil engine, patented by a local inventor. Eight lamps of 16 C.P. each were lighted and burned very steadily and satisfactorily.

The Electric Light on the Midland Railway.—Some experiments are at present being carried on by the electrical engineers of the Midland Company in the lighting of the through trains between Bradford and London. The supply of electric current is obtained from accumulators constructed in the carriages, and can be turned on and off at the will of the guard having charge of the train. The electrician and his assistant travel with the trains for the purpose of observing the result.

The Ballarat School of Mines.—This school of science, which is at the University of Melbourne, comprises amongst others, a class for telegraphy. We observe from the report for 1889, a copy of which has been forwarded to us, that since 1874, over 250 certificates have been granted.

Light in Dark Places.—It is proposed to substitute electric lighting for gas in the Chamber of Deputies at Paris.

Electric Lighting at Bath.— Mr. Massingham's application to the Board of Trade for a licence to supply the electric light in Bath will probably form the subject of a public inquiry, the local gas company having intimated their intention of opposing the granting of the license. The Town Council has already unanimously decided to support Mr. Massingham, whose position is, therefore, a very strong one.

The American Eagle.—The picturesque stories which reach the other side of the Atlantic on the subject of American machinery are only equalled by the accounts which are published there of the success of American actors and actresses in London. The *Safety Valve* is an American journal, of which we have not previously heard, but we find the following quotation from it in an American industrial paper. Our readers will find, on perusing it, that this safety valve is blowing off steam. "The Metropolitan Electric Light Company operates a number of large central stations in the city of London. One was recently equipped with an outfit of Westinghouse compound engines. Another station operated in the same city by the same company is equipped with single-acting engines of English make. Quite a good-natured rivalry exists, of course, between the men who are in charge of these stations. Recently, the American engines were put through their paces by British experts, on behalf of the Metropolitan Company, in a test lasting twelve hours without intermission. 'It was amusing,' says the Westinghouse Machine Company, 'to see the interest taken in the test by the American colony in London, many members of which spent the greater part of the day in the station. Even our respected Minister Plenipotentiary and Envoy Extraordinary, Mr. Lincoln, was on hand to see the American Eagle properly comforted and encouraged in its hour of trial. Being called away on important business he returned at a later hour, in order to make sure that the American interests and American dignity were being properly upheld. The engines in question are running regularly under a very heavy service, and the experts subjected them to many severe tests during the day; but they behaved so splendidly in all respects that Englishmen were agreeably surprised. Some of the Americans who took such a lively interest in this test really knew very little about steam engineering, but they are wildly enthusiastic at the way in which these upheld America's reputation for good machinery in London.'" The American Eagle, since reading the foregoing, has, we understand, grown two new feathers in its tail.

Telephony in Germany.—The compositors made us say in our last issue under this heading that a desire had been expressed in the Upper Siberian districts for telephonic communication between Berlin and Ratibor. This should, of course, have read "Upper Silesian districts." Siberia can wait a little longer.

New Mode of Producing Electricity.—Our contemporary the *Daily News* has got a little bit of an electric craze, which induces it to publish the most surprising information on technical matters. The latest thing is the following:—"A grand organ is being built at Crema for the Sanctuary of Valle di Pompei. . . . A petroleum engine will be used to blow the bellows of this immense organ. It is made after a Belgian model, and will in the evening develop sufficient electricity to supply light to 26 lustres." This knocks primary batteries into fits. It is not quite clear from the wording whether it is the petroleum engine or the organ which generates the electricity, but whichever it be, the invention is a remarkable one. It is not mentioned whether the organ is played at night, but, if so, it or the petroleum engine must do double work at that period.

Dangers from Electric Shocks.—We cannot for the life of us understand whether Mr. W. H. Preece is a serious man or an incorrigible wag. In commenting upon the paper read by Messrs. Harries and Newman Lawrence he is reported to have said, "the difficulty was to kill rather than to prevent being killed." His remarks on the subject of danger from electric currents were so severely criticised at the time of the British Association meeting that we should have given him credit, when another occasion arose to display his profound contempt for shocks, for more moderation, but here we find him going further and further out of his depth.

Steam Engines for Electric Lighting.—Messrs. Marshall, Sons & Co., of Gainsborough, have just issued a new edition of their illustrated catalogue of prize steam engines and machinery (industrial section), in which particulars and prices are given relating to a number of engines which have been found, after lengthened trials, to be specially adapted for use in central lighting stations or private installations. It being of the utmost importance to the electrical engineer that the largest amount of power should be obtained for the quantity of fuel consumed a preference is generally given to the compound engine, either portable or stationary. With an engine of this class, fitted with patent automatic expansion valve gear, the quantity of steam used is regulated in exact proportion to the duty required from the engine, thus increasing its economy in fuel consumption and maintaining uniformity of speed under frequent and sudden variations of load. Two engines of this type, each of 40 H.P., are running at the Tithebarn Street Station, Liverpool, and three of 20 H.P. each at Peter Robinson's, Oxford Street. At the Prudential Assurance Offices there are three engines, and at the Grosvenor Gallery four, of the horizontal fixed type by these makers, each of 35 H.P., while at the British Museum there are two of 30 H.P. each. Another class of engine largely used for electric lighting, and specially recommended for small installations, is Marshall's vertical engine, from 2 to 14 H.P. They are simple in construction, easily managed, and, by means of an improved governor, the speed is regulated under varying loads. Engines of this make have been supplied for private house lighting to Dr. Hopkinson, Mr. Mather (Mather and Platt), Mr. Parker, of Wolverhampton, and many others. Large compound vertical engines have been adopted by the Bradford Corporation and the Liverpool Electric Supply Company—in the former case the H.P. being 170, and in the latter 130. The firm of Marshall and Sons have supplied the engines for so many installations that they are able to give a list of the principal ones, numbering over 200, including the Bank of England, British Museum, Royal Courts of Justice, Hôtel Metropole, General Post Office, the offices of the *Standard*, *Telegraph* and *Star*, the Woolwich Arsenal, and many others equally well known, not only in this country, but in many other parts of the globe.

A Mystery.—A correspondent wants to know the import of the following remarkable inscription which figures above the ground floor windows of Messrs. Woodhouse and Rawson's premises in Cannon Street. It runs:—

W E R B

We really do not know what is the signification or import of the above, but possibly it is a new formula.

Obituary.—It is with regret that we record the death of Mr. James Clarkson Johnson, late partner in the firm of Messrs. Johnson and Nephew, of the Bradford Ironworks, Manchester. The business will be carried on by the remaining partner, Mr. John Thewlis Johnson, together with his son, Mr. Herbert Johnson, who is admitted as partner.

Faith in Electric Traction.—"The recent negotiations," says the *Western Electrician*, "in electric railways give evidence of the faith of capitalists in the new system of street car propulsion. One capitalist alone has invested over five million dollars during the last few months in street railways, which he proposes to convert into electric roads." The enthusiast is Mr. H. S. McKee, of Pittsburgh, and he has selected the Thomson-Houston system for the Buffalo and Newark lines. The contracts, it is said, will be enormous.

Lecture.—On Friday evening last Mr. S. W. Baynes, electrician to the Bradford Corporation, delivered a lecture to the Bradford Scientific Association upon the electric light. The different systems of lighting were described, and secondary batteries and electric light meters were shown in operation.

The Institution of Electrical Engineers.—On Thursday, the 10th inst., at the ordinary general meeting, a paper "On Signalling across Rivers in India," by W. T. Melhuish, member; and another on "The Diathermancy of Air in relation to the Efficiency of Incandescent Lamps," by Frederick Higgins, member, will be read.

Afraid of the Expense.—Some opposition has been raised to the lighting of the parish of Weybridge by electricity on the score of expense. It is feared that the permanent installation of the electric light would involve a large increase in the lighting rate, and a committee has consequently been formed to discover the best means of banishing the new illuminant from this enlightened portion of Her Majesty's realm. It remains to be seen whether this reactionary movement will meet with any degree of success.

Central Station in Breslau.—The Town Council of Breslau has just commissioned Messrs. Siemens and Halske, of Berlin, to erect a central station in the former town. The initial capacity will be 10,000 16-C.P. lamps and the station is to be completed by the autumn. It is proposed to employ steam engines coupled direct to dynamos of 250 H.P., and probably accumulators will also be used.

Electric Tramcars in Berlin.—Negotiations are proceeding between the General Electric Company of Berlin and the principal local tramway company, with a view to the introduction of electric traction on the latter's system. The first line to be worked is the portion called Friedrichstrasse-Kreuzberg, and operations will be commenced as soon as the Berlin Municipality has given its consent to the employment of electric tram-cars. Only half the number of cars on the line in question will be fitted electrically. The reason for this is because the cars are small, and two cars will be coupled together. The cost of equipping each car is estimated at £50 (?) and the power of the motor is reckoned at 5 H.P.

A New Verb.—Mr. Geo. Offor has sent us a letter in which he suggests a new term to describe the propulsion of electric launches. We see no harm in our correspondent adopting the verb, "To Electrick," with a k, but we cannot encumber our pages with his reasoning for inflicting this atrocity upon others.

Brazilian Rubber.—Last week, Mr. James W. Wells, M. Inst. C.E., F.R.G.S., read a paper before the Foreign and Colonial Section, of the Society of Arts, on "Brazil," in the course of which he pointed out that the prominent question with regard to that country is what is going to happen next and will it settle down peaceably under the new order of things. Mr. Wells is cautious, and did not commit himself to giving a definite reply to his own query, but he told his auditors something about rubber and other products. He has a high opinion of the resources of the country and asserted that India-rubber trees, if properly cultivated, would at the end of ten years return 150 per cent. on the capital expended on the plantation. This expression is vague, but from detailed figures subsequently given, it appears that what he meant to convey was that after allowing for capital sufficient to work an estate for ten years without any return, an annual profit of 150 per cent. on the total outlay would be forthcoming. He advocated the establishment of such estates, which he considered would soon be imperative, owing to the increased demand for rubber in various industries. "The Amazons is," he said, "the great supplier of the rubber market, but every year the gangs of rubber gatherers have to proceed further and further in search of the valuable sap, leaving almost invariably behind them a track of exhausted rubber trees. In fact, the present crop is reported to be 1,000 tons short.

The Telephone in America.—The annual report of the Bell Telephone Company shows the number of telephones in use in the United States to be 450,380, or more than 33,000 than a year ago. Dividends of 18 per cent. to the amount of $183,913 were paid, leaving a surplus of $2,151,012. The net receipts for the year are 23·55 per cent. on stock.

Treatment of Goitre by Electricity.—Dr. Marano reports the complete cure, by electricity, of a goitre of considerable size and three years' duration. The treatment took the form of strong faradic currents externally and electrolysis alternately. For the latter purpose he used five to eight Leclanché's cells, a sponge held between the patient's hands for the positive pole, and connected with the negative pole, a glover's needle, which he inserted into the tumour. On two occasions he connected both poles with needles plunged into the gland. One or two electrolytic and one to three faradic *séances* were given weekly, the former lasting for five minutes, and the latter ten to fifteen. Improvement appeared after first *séance* in the subjective symptoms, a marked diminution of the tumour was visible by the sixth; and though after the first month the progress was less rapid than previously, the swelling ultimately disappeared completely.

Execution by Electricity.—The murderer Kemmler has been finally sentenced to be executed by electricity during the week beginning April 28th.

The Jubilee of the Penny Post.—At the meeting of the City Common Council, on Thursday last, a letter was read from Sir Arthur Blackwood, secretary to the Post Office, on the subject of the celebration of the Penny Postal Jubilee and asking the court for permission to utilise the Guildhall and its spacious library and council chamber for the purposes of a conversazione, at which should be displayed and illustrated by the Post Office all kinds of postal work and industry, together with electric telegraphy, and a collection of the postage stamps of all nations. It was resolved that the request should be complied with, and that the arrangements should be made by a committee.

The Dangers of Electricity.—The *Daily News* Paris correspondent telegraphed on Monday: Mr. Edison, when last here, said it was dangerous to be sending side by side with gas conduits through subterranean Paris electrical currents by wires charged with high tension currents. He foresaw gas explosions, and an explosion has, owing to this cause, taken place at 26, Boulevard des Italiens, a leaden gas pipe having melted. A window was shattered. It appears that accidents of this kind are constantly taking place, and that within fifteen months they have caused large losses. A Reuter's telegram from New York says that a grain mill at St. Louis, the property of Messrs. Kauffmann, was on Friday destroyed by fire, the building being ignited by an electric wire. The loss is estimated at $200,000.

Protection of Submarine Cables.—The text of the convention for the protection of submarine cables held in Paris has just been published as a Parliamentary paper. It is a punishable offence to wilfully damage a cable to the interruption of telegraphic communications; but this clause (No. 2) does not apply to those who injure it with the object of saving life or their ship. If the owner of a cable damages another one he must repair it, and that without prejudicing a penal action which may be instituted. It is compulsory for all vessels and fishing boats to keep a mile away from any ship engaged in laying a cable. Owners of vessels who can prove that they have sacrificed gearing or anchors in order not to injure cables can recover the amount from the owner of the cable if made at once. The treaty, which is an international one, and applies to our colonies, remains in force for five years, and is to be renewed yearly.

A Telegraphic Tournament.—Mr. A. B. Chandler, president of the Postal Telegraph and Cable Company, U.S.A., in forwarding a subscription of $50 towards the expenses of the forthcoming fast-sending telegraphic tournament, points out that "desirable as is high speed, still more important is accuracy," and he offers a prize of $10 to the operator who shall be adjudged the clearest and best sender, regardless of speed, and another $10 prize to the receiving operator who shall make the best "pen and ink copy," including all "earmarks" required for the identification and record of the messages.

Probably an Error.—A subscriber to the telephone exchange asked to be placed in communication with his medical man. *Subscriber:* "My wife complains of a severe pain at the back of her neck and occasional nausea." *Doctor:* "She must have malaria." *Subscriber:* "What's best to be done?" At this moment the clerk at the central station alters the switch by mistake, and the unlucky husband receives the reply of a mechanical engineer in answer to enquiries of a mill-owner. *Engineer:* "I believe the inside is lined with excoriations to a considerable thickness. Let her cool during the night, and in the morning before firing up, take a hammer and pound her vigorously. Then get a garden hose with strong pressure from the main and let it play freely on the parts affected." To his great surprise the doctor never saw his client again.—*Electric Age.*

A Bill for Electric Traction.—The North Metropolitan Tramways Company has obtained the Bill for the application of electric traction to the whole of their system.

A New Car Approved.—General Hutchinson, Inspector to the Board of Trade, last week inspected and approved of the car which the Electric Traction Company are about to run for experimental purposes on the Liverpool United Tramways. To meet the heavy gradients on this line a heavier motor will be used, and both axles will be operated.

Electric Launches.—Messrs. J. B. Seath & Co., the well-known boat builders of Glasgow, are making great progress with the electric launches mentioned last week which are to be run on the canal during the forthcoming Exhibition at Edinburgh. Each boat will carry 30 or 40 passengers, landing them most conveniently at the entrance to the building. It is also intended to run pleasure trips during the season.

Telephonic Communication with Government Offices.—In the House of Commons, on Tuesday night, Mr. P. O'Brien asked the Secretary to the Treasury whether all or any of the Government offices in London were connected with the telephone erected for the use of members within the House of Commons; and, if not, whether, considering the great convenience it would be to members for making inquiries and appointments, he would have connections established. Mr. Jackson said that although telephonic communication with the Government offices might be of some convenience to members, he was afraid he could not say the same with respect to Ministers. To them it would be very inconvenient. Suppose, for example, a member wished to communicate with the Treasury upon some matter of business. There would probably be involved a communication from the Treasury to himself, and he would in all probability be in the House. Inasmuch, therefore, as the convenience would only be available to members during the sitting of the House, and all the Government offices were represented in the House, it would be more convenient that a communication, if urgent, should be made direct to the member of the Government responsible for the office with which communication was desired. All communications on Government business made to a Government department should be subject to the authority and supervision of the head of that department.

The Institution of Electrical Engineers' Discussion.—Mr. Mordey wishes us to correct, in so far as his remarks are concerned, the official report of the discussion which took place before the members of the Institution of Electrical Engineers on the papers of Messrs. Swinburne and Esson. On page 383, from line 8, to the end, substitute:—"The brush machine had been shunt wound for arc lighting and many machines were so working, but the plan was only suitable for special cases. For light loads it was unsuitable, and on the whole the series method was best. As to the heating of the polepieces, he pointed out that there were two causes of unequal heating—one was the action of magnetic tufts which always heated the same pole, the trailing horn; the other, and more important, was the action set up by the current in the armature coils. The pole heated most by this latter cause was behind the brush in a generator but in front of it in a motor. Thus if a brush machine is run with the brushes in the same place as a motor as when used as a dynamo—as may be done by reversing the field—the same polepiece will heat in both cases, but in a motor the heat will be less, because the two causes of heating referred to are not acting on the same pole. In a dynamo the effects are added, in a motor they are subtracted."

Electricity in Court.—One of the Paris Courts has got to decide the question whether a landlord can prevent his tenants from installing the electric light on the premises. In the particular lease there is a clause forbidding the tenant to make alterations in the internal arrangements of his premises without the landlord's written consent; but the latter's counsel apparently prefer to rely upon learned and long dissertations on high and low tension, the effects of induction, &c. One of these learned gentlemen disposed of an argument, based upon some remarks of Mr. Edison about the dangers of high tension subterranean canalisations, by saying that Edison was out of court, since he only sold low-tension currents.

West African Rubber.—An important company has just been formed for purchasing the valuable concession granted for the sole right of collecting and exporting the India-rubber grown within the territories of the Government of Liberia, West Coast of Africa, the concession covering the whole area of the government lands on which the gum elastic rubber tree is found, and it is estimated that a minimum of 2,000 tons can be collected annually. It is stated that brokers in London have offered to take any quantity of the Liberian rubber that he sent them at prices varying from 1s. 6d. to 2s. 9d. per lb.

Capital and Labour.—We have received a lengthy letter from a correspondent on the subject of electrical workmen and wages, but our space is too much taken up this week to allow of its insertion. We shall probably have a few comments to make upon the writer's ideas of fair play in our next issue.

City of Paris.—When the late disaster occurred to this Atlantic liner the dynamo room got swamped, and other means had to be trusted to for light.

Electric Companies' Mains.—The County Council has granted permission to the Metropolitan Electric Supply Company to lay mains in the principal streets and squares of the West Central district, on condition that three days' notice is given to the Council's engineer, that the mains shall be enclosed in 5-inch iron pipe and laid under the footways wherever practicable, and that the covers of the boxes shall consist of iron frames filled in with material to suit the paving. Sanction was also given to the Kensington and Knightsbridge Company for the laying of mains.

North German Telegraph Cables.—The German Government has purchased the telegraph cables between Hamburg-Cuxhaven and Heligoland for £9,600.

Edinburgh Lighting.—Lord Balfour of Burleigh and Mr. Courtenay Boyle, C.B., representing the Board of Trade, recently received a deputation from the Town Council of Edinburgh on the electric lighting question. The council wishes to control the city lighting, and with that view will apply for an order as early as possible; but there are several lighting companies already in the field. The corporation has refused its consent to the applications of the latter, but is not quite clear as to whether it constitutes the "local authority" mentioned in the act. As regards this point, Lord Balfour thought there could be no doubt that in the case of Edinburgh the Town Council was the local authority for electric lighting purposes under the act. Later in the day representatives of the various companies waited upon Lord Balfour and Mr. Boyle, when the town clerk and Mr. Beveridge, the corporation's Parliamentary agent, were present, and urged that, having done everything in compliance with the statute the companies *prima facie* were entitled to proceed. At the conclusion of the interview, Mr. Beveridge said it was clearly to be understood that, if there should be any postponement of the inquiry, that would not debar the corporation taking the necessary steps next November if they saw fit.

The Grievances of Telegraphists.—The following is the resolution which Lord Compton will move on Tuesday, the 15th, with reference to the telegraphists:—"That, in the opinion of this House, the present position of telegraphists in London and elsewhere is unsatisfactory, and their just grievances require redress."

Overhead Wires at Exeter.—The vexed question of overhead wires was under discussion by the Exeter Town Council last week. The secretary of the Exeter Electric Light Company made formal application for permission to erect three standards in Northernhay Place, and this gave rise to a protest against an authorisation being given which would lead to an extension of overhead wires, which the mayor said were an eyesore and might prove a nuisance. It was further urged that so long as the council gave permission for wires to be erected overhead nothing would be heard of their being put underground. On the other hand, it was submitted that if the company chose to erect overhead wires, with an intention of putting them underground in two years, the council could not complain, inasmuch as they were spending the shareholders', and not the ratepayers' money. Eventually it was resolved by 21 votes to 16 that permission should only be granted on condition that the wires be laid underground. Alderman Domville gave notice of his intention to move a resolution instructing the surveyor to remove all existing overhead wires.

A Shareholder's Suggestion to the Torquay Gas Company.—At the meeting of the Torquay Gas Company, a few days since, Mr. Iredale, one of the shareholders, offered the directors a little advice on the subject of electric lighting, which does not, at all events at present, appear to meet with their approbation. He said the electric light had now been before the country for some years. It was year by year receiving more attention, and becoming more perfect; and a few years hence there would be a considerable fight between the two great lights—electricity and gas. His impression, as a shareholder, was that the company should make application for Parliamentary powers to enable them to light the town by means of electricity, for the reason that they would have outside competition unless they "took the bull by the horns" themselves. That the electric light would be introduced into Torquay, sooner or later, he regarded as almost a certainty; and the question was, who should do it? He maintained that it should be done by the company who at present held the powers of lighting the town by gas.

Government Telegraphs and Railway Companies.—Says a morning contemporary:—When the telegraphs were handed over to the Government a bargain was made with the railway companies by which, in part payment of way-leave, they were permitted to transmit messages on the business of the company free of cost. In 1871, upon the transference of the telegraphs, 97,000 such messages were sent. In 1888, the last period at which statistics are available, these messages had risen to a number falling very little short of a million. It is estimated that a loss of £50,000 a year accrues to the revenues from this source. Mr. Heaton is pressing the Postmaster-General to introduce a Bill terminating the arrangements.

Electricity in Montevideo.—Early in March one of the electric wires at the corner of Calle 18 de Julio broke and fell on the road. Two horses in a market cart passing by were thrown down by the electric current the moment they touched the wire, which was giving out sparks as it lay on the ground, and the driver was thrown off his seat. A policeman attempted to clear the wire from the horses' "feet" with his sword, when he was immediately knocked down by the force of the electricity. He managed to get on his feet, but was again knocked down. Some of the lookers-on went and pulled him off the wire, and in doing so one of them was knocked down, but managed to save himself by rolling off the wire. Immediately afterwards a tram-car drawn by three horses arrived, and all the animals fell on coming into contact with the wire. By this time the men of the electric light company appeared on the scene. One of them was for a time prevented by the police from trouching the wire, but afterwards one of them seized the wire with a tongs to try to cut it, and was at once thrown on his back; but the tongs fell from his hands and he was able to get up again. Some more of the company's men arrived shortly after, and the horses were rescued. The men then set about to repair the wire in order to get light in the Calle 18 de Julio and other streets that were in darkness all the time.

Electrical Exhibition in New York.—An electrical exhibition will be opened at the Lennox Lyceum, Fifty-ninth Street and Madison Avenue, New York, on Easter Monday, and continue until May 17th. The starting of the scheme is due to a liberal contribution of $5,000 from Mr. T. A. Edison, who has also offered the use of his entire Paris exhibit. Among other companies, the Bell Telephone Company, the Edison Electric Illuminating Company, the Metropolitan Phonograph Company, and the Sprague Electric Railway Company, have been invited to take part in the exhibition. The Sprague Company proposes to construct several operative miniature railways with automatic signals. Other attractions will be an apparently submarine telephone connection with all parts of the world, a phonographic library, and a large supply of phonographs, in which cylinders containing speeches by famous men will be in operation.

NEW COMPANIES REGISTERED.

Patent Lithographic Zinc Plate Company Limited.—Capital £10,000 in £5. Objects: To acquire the manufacturing rights of Oscar Kindermann and his partners in the process of preparing zinc plates for lithographic purposes, and to construct and maintain such manufactories, warehouses and electric works as may be necessary. Signatories (with 1 share each), *A. K. Dibb, *Henry Willford, *W. Schultetus, W. R. Locking, *N. Y. Owbridge, C. H. Dibbs, A. W. McIlwaine, all of Hull and neighbourhood. The

signatories denoted by an asterisk are first directors. Qualification, 50 shares, the company in general meeting will determine remuneration. Registered 29th ult., by Messrs. Waterlow, Bros., and Layton, Birchin Lane.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Priestman Oil Engine American Syndicate, Limited.—The statutory return of this company, made up to the 7th ult., was filed on the 19th ult. The nominal capital is £25,000, divided into 1,250 preference and 1,250 ordinary shares of £10 each. 1,250 shares have been taken up, and £2 10s. per share has been called, the calls paid amounting to £3,000, and unpaid to £125. The document does not state whether the subscribed shares are preference or ordinary. Registered office, Temple Buildings, Kingston-upon-Hull.

Mining and General Electric Lamp Company, Limited.—An agreement of 28th ult., between this company and the liquidators of the New Portable Electric Lamp and Power Syndicate, Limited, provides for the allotment of 34,115 fully-paid shares of £1 each, being the balance of purchase money due for patents purchased from the syndicate company.

Birmingham Electric Supply Company, Limited.—The statutory return of this company, made up to the 17th ult., was filed on the 25th ult. The nominal capital is £100,000 in £5 shares. The shares taken up are 8,701 ordinary and 1,800 ordinary special issue. Upon the former £1 per share has been called, and 5s. per share upon the latter; the calls paid being £8,598 10s. and £450, respectively. The calls unpaid amount to £102 10s. Registered office, 120, Colmore Row, Birmingham.

An extraordinary general meeting of the company was held on the 3rd ult. at the Queen's Hotel, Birmingham, when the following resolution was passed unanimously, viz. :—"That of the subscribed capital of the company £50,000 be, and the same is hereby appropriated as a separate capital for the purpose of the undertaking authorised by the Birmingham Electric Light and Power Order, 1889." The resolution was confirmed on the 19th ult., was duly filed on the 27th ult.

Key's Electric Company, Limited.—The registered office of this company is situate at Ingram House, 165, Fenchurch Street.

Durand Electric Petroleum and Gas Engine and Manufacturing Company, Limited.—The registered office of this company is situate at 175, Strand.

Armstrong's Electric Light and Power Company, Limited.—The registered office of this company is now situate at 31, Aldermanbury, E.C.

CITY NOTES, REPORTS, MEETINGS, &c.

The London Electric Supply Corporation, Limited.

IN the annual report submitted to the meeting of shareholders, a report of which follows herewith, it is stated that the board have carefully considered the means of turning to better advantage the plant at the Grosvenor Station, and have decided to remove it to Deptford. The arrangements already made for this change are described in the engineer's report. It is obvious that the concentration of the whole of the generating machinery in one establishment, under the control of the chief engineer, must secure material advantages in supervision and economy.

During the past year the corporation has acquired statutory powers over a large area of the metropolis, embracing thickly-populated and busy districts, from which the board believe that a lucrative business may be obtained. These powers have only been acquired with much labour and expense, and after a protracted and costly local enquiry by the Board of Trade, and subsequent proceedings in Parliament. The board have every reason to be satisfied with the results secured for the corporation, due, in no small degree, to the personal exertions of the Earl of Crawford, whose attention to the interests of the corporation was unremitting. Your directors are applying for further powers this session, which, if granted, will considerably enlarge your statutory area, and will lead to a more economical disposition of the corporation's works.

The applications for current now in hand, and which are growing from day to day, justify the expectation that for a long time to come there will be full and profitable employment for the plant of the corporation. Owing to the allocation to the Metropolitan Electric Supply Company of some of the districts hitherto supplied by the corporation—notably the parish of Marylebone and the Strand District—the corporation's customers and works in those districts are being handed over to that company, with whom a satisfactory arrangement has been made by which the corporation receives the cost of and other adequate considerations for the works and appliances so transferred to them.

The accounts show a balance to the credit of profit and loss account, from which your directors recommend that the dividend of 6 per cent. upon the preference shares be paid. This will allow of a small balance being carried forward.

In the capital account it will be seen that £2 per share of the preference capital has been called up, leaving £3 per share still due. Having sufficient capital for their immediate requirements, the board have not made the further calls they were empowered to make, being of opinion that in the recent state of the money market it was more in the interest of the preference shareholders that the money should only be asked for when required. It is therefore proposed to call up the remainder of the preference capital at such intervals as may be necessary. In view, however of the conditions of the prospectus, the board will afford to the preference shareholders the option of paying up the balance due on their shares whenever convenient to them between the present date and the 30th June next.

During the past year the Earl of Crawford has resigned the chairmanship, but the board are happy to say that he is continuing his services as deputy chairman. Mr. James Staats Forbes has been elected chairman. The directors retiring, as provided by the articles of association, are the Earl of Crawford, Sir Coutts Lindsay, and Lord Wantage, all of whom are eligible and offer themselves for re-election.

The engineer's report reads as follows :—

"I have the honour to report that during the past year the general works and buildings at your Deptford Station have been completed, and a large amount of machinery for supplying electric current has been erected. There is now in complete working order a plant consisting of two 30,000-light dynamos, with engines, boilers, and other accessories to correspond.

"In order to utilise this supply of current in London, mains were purchased and laid in the early part of last year, but I regret to say that some of them have proved a very great failure, owing to which you are not in a position to utilise more than one-quarter of the capacity of your Deptford plant. Had these mains succeeded you would now have been in a position to utilise the whole of the Deptford machinery above-mentioned for the supply of the corporation's customers in town.

"The Grosvenor central lighting station has continued to supply current to a large number of consumers during the past year, notwithstanding the great difficulties attending its position in a most populous and busy district, where space and every other convenience are much limited. In order to use the plant of this station to its full advantage, and to secure the benefits of the riverside site, arrangements are now being made for its removal to Deptford, where, before the autumn, it will be in a position to contribute to the supply of light in London in a more economical and efficient manner than now. You will then possess plant capable of generating power for 90,000 lights, with which, after making most liberal allowances for reserve, you will be able to supply 60,000 lights simultaneously.

"In addition to the above two large dynamos of the capacity of 200,000 lights each are being built. These machines will at first be used for 100,000 lights each, and the engines and boilers for this output are now completed, and the machines themselves are in a fairly advanced state, the heaviest and most difficult parts of them being well in hand. It is expected that these machines will be completed about the end of the present year, when the productive capacity of your plant will be raised to 290,000 lights, and, allowing for reserve in accordance with the requirements of the Board of Trade, you will be able to supply some 160,000 lights simultaneously. At a later stage the current for 200,000 additional lights will be obtained from these machines by simply adding the necessary engine power.

"The laying of distributing mains has been commenced, and fair progress made in a portion of the corporation's area. The manufacture of permanent trunk mains by the corporation's own staff has been vigorously pushed forward, but partly on account of the time occupied in getting a new system into working order, and partly owing to the great difficulties experienced in meeting the varying requirements of the several local and other authorities, none have yet been laid. These mains have been tested on the corporation's own premises, and the results show that they are capable of withstanding greatly more electrical pressure than will be required in ordinary working, and also that they are in every sense a practical and commercial success. The defective mains now in use between Deptford and London will shortly be replaced by these permanent trunk mains, when a supply of current to the full capacity of the machinery now erected at Deptford may be utilised.

"During the past year great difficulty has been experienced in obtaining a satisfactory meter for the registration of current supplied to customers, and this difficulty has entailed a certain amount of loss to the corporation. Recently, however, several meters of a satisfactory type have been put into use, and now more than half the corporation's customers are supplied through these meters. It is believed that before very long the corporation will be able to supply all their customers by meter.

"It may be well here to remind the shareholders that in erecting its works at Deptford on a site immediately adjacent to the Thames, and upon a sufficiently comprehensive scale, the corporation has taken its lesson from the gas companies. These companies commenced with small stations in the centre of populous districts, but experience has since shown that this was an undesirable method of proceeding, and that the true way to secure both economy and efficiency is to generate gas on a large scale on a commodious site at the water's edge, and at some distance from the district to be supplied. The corporation has followed this eminently practical conclusion, and when the Deptford works are further advanced the wisdom of following an example proved to be so successful in an enterprise of a kindred nature will be apparent.

"S. Z. DE FERRANTI."

The third ordinary general meeting was held on Monday at the City Terminus Hotel, under the presidency of Mr. J. S. Forbes. The chairman referred with great regret to the resignation, mainly for reasons of health, of the Earl of Crawford, who until recently had presided over the company. As the works were now approaching completion and the company was likely to develop at no distant time into a working undertaken his (the speaker's) colleagues had thought that he might be of some service to them by taking the post previously occupied by Lord Crawford. The accounts were presented upon the model required to be made by the Board of Trade, and he thought that they rested upon this possibility—that in accordance with the conditions on which this and similar companies had come into existence there might be a time when some other interest—local authority or otherwise—might acquire the right of taking over the enterprise upon certain terms set forth in the concession, charter, or provisional orders belonging to them. The company were authorised by their articles to raise £1,000,000, divided into 200,000 shares of £5 each, of which 111,000 were issued and paid for. For their future requirements there remained to be issued 89,000 shares, representing £445,000, making up the balance of £1,000,000. There was no immediate probability of that part of the capital being increased. Comparatively recently the shareholders had also authorised the directors to create preference shares of £5 each to the amount of £250,000, in order to get rid of the incubus of a debenture debt. Upon this issue £2 a share had been called up, leaving unexhausted £150,000 under this head available for the future requirements of the company. They started the year 1889, having expended on capital account £373,703, and during the year they had spent the shareholders' money somewhat rapidly, the outlay having been £131,555. They had received on capital account £649,750, and the balance unexpended of that amount was £144,491. They, therefore, had this last mentioned amount and the £150,000 unpaid on the preference shares assured to them in order to complete and develop their undertaking, in addition to which they had the reserve of ordinary capital which he had mentioned. They believed that the resources in hand were fully sufficient to carry out the undertaking as far as their existing powers were concerned. Passing on, he observed that their enterprise could not be brought to perfection without their having to find out a great many things as they went along, and he was sensible that the accounts contained a great many items of expenditure which were very large in proportion to the result achieved. They had received on this account £27,638, and the balance of profit was only £1,249; but for the same expenditure they could, undoubtedly, have sold a great deal more current at 7½d. per Board of Trade unit, a great deal more current under contracts, and have obtained a great deal more rental from meters, &c., than they had done in the past year. He hardly knew any enterprise upon which Parliament had a voice which had been so hampered and obstructed as the electric light. After referring in detail to some of the difficulties that had to be overcome even under existing legislation, he said that he felt convinced that next year they would show a better result on the revenue account than they did in the statement now submitted. Owing to the allocation to the Metropolitan Electric Supply Company of some of the districts hitherto supplied by the London Corporation, the customers and works of the latter in Marylebone and the Strand were being handed over to the Metropolitan Company. That company and themselves had what might be called the lion's share of London, and they were working on friendly terms with each other. As the result of the year's operations they were enabled to pay a dividend of 6 per cent. on the preference capital which had been received up to December 31st, and to carry forward a balance of £920. Turning to the directors' report, he alluded to the report of the engineer appended, and spoke of the wisdom of concentrating their works at Deptford. They had taken a lesson from the gas companies, whose experience, as Mr. Ferranti said in his report, "had shown them that the true way to secure both economy and efficiency was to generate gas on a large scale, on a commodious site by the water's edge and at some distance from the district to be supplied." As soon as they were in full working order at Deptford they would cease to generate the current at the Grosvenor Gallery, although that would still be a centre of supply. The applications for current were growing from day to day, and they could not meet the demands of the public upon them at present. They had adopted the high-tension system, which was different from that which other electric light companies had adopted. The experiment was now being tested by practice, and, like all experiments, it was not achieved in a single day, and a great many difficulties had to be overcome. Mr. Edison had visited the works, and had been astounded at what he had seen. Mr. Edison's lieutenant also subsequently visited the works, and had gone further than Mr. Edison in his comments, also stating that they had done the right thing in concentrating their works at one place.

Lord Wantage seconded the motion.

A short discussion followed, in which Mr. Benjamin Kisch, Mr. Scott Russell, and the Lord Justice Clerk (Lord Kingsburgh) took part.

The Chairman having replied, the motion was unanimously adopted, and resolutions were afterwards passed declaring the dividend recommended, re-electing Earl Crawford, Sir Coutts Lindsay, and Lord Wantage to their seats at the board, and reappointing the auditors, Messrs. Kemp, Ford and Company.

Fareham Electric Light Company, Limited.

THE first general meeting of this company was held last week at the Foresters' Hall, Fareham, when Capt. Ramsey occupied the chair. Mr. James Blake, speaking of the company's position, stated that a contract had been entered into between them and Messrs. Laing, Wharton and Down, the syndicate working the Thomson-Houston system. He thought the system would prove a beneficial one, as it had been adopted with so much success in many parts of the metropolis. A contract for steam power had been entered into with Messrs. Ransomes, Sims and Jeffrey, of the Orwell Works, Ipswich, for 105 indicated H.P. They had authority from the Fareham Local Board to enter the town and erect all the necessary plant and appliances for supplying the electric light, subject to the rules and regulations of the Board of Trade. An advantageous site for building a station was at their disposal. He should think the company would be able to supply the light generally to the town in about three months.

The usual vote of thanks to the chairman concluded the meeting.

A battle of posters has been lately waged in Fareham, principally with reference to the electric light question. The managing director of the Taunton Electric Light Company writes in reply to certain statements affecting the company, emanating from Mr. C. Bovill Smith, of the gas company. He regrets to say that not only are the statements inaccurate and misleading, but a gross perversion of the truth; in fact, some of them are pure inventions. During the three years the Taunton Electric Light Company has been established it has paid dividends amounting to 16 per cent. on the total paid up capital, besides carrying forward a balance of £352 9s. 10d., and has never devoted, as was asserted, a single penny of capital to the payment of dividends. The promoters of the new company express their intention to offer the electric light to the Local Board for public lighting purposes for a sum of £460 a year, supplying lamps representing 16,000 C.P. (the present gas illumination represents but 2,000 C.P.), at the same cost as that at present incurred for gas.

The Eastern Telegraph Company, Limited, announce the payment on April 15th of interest of 3s. per share, less income tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ending March 31st, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, tax free, in respect of profits for the quarter ended December 31st, 1889.

The Telephone Company of Austria, Limited, intimates that the usual half-yearly dividend to the 31st inst. on the preference shares, at the rate of 6 per cent. per annum, payable, less income tax, early in April, has been declared by the board.

Anglo-American Telegraph Company, Limited, have declared an interim dividend for the quarter ending March 31st, 1890, of 12s. 6d. per cent. on the ordinary stock, and 25s. per cent. on the preferred stock, payable on May 1st.

The Commercial Cable Company.—It is notified that a quarterly dividend of 1¼ per cent. will be paid upon the outstanding stock on the 10th inst. to all stockholders of record on April 1.

Direct United States Cable Company, Limited.—The directors have declared a quarterly interim dividend of 3s. 6d. per share, payable on the 24th proximo.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending March 28th, 1890, amounted to £4,558.

The Cuba Submarine Telegraph Company, Limited. The estimated traffic receipts for the month of March were £4,000 as compared with £4,540 in the corresponding month of last year. The receipts for the month of December, estimated at £3,000, realised £3,995.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 28th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,515.

MARK TWAIN'S SCIENCE.

WE extract the following from a review of Mark Twain's new book, "A Yankee at the Court of King Arthur." We have briefly referred to this remarkable volume in our front pages :—

In Camelot the Boss, Clarence, and 52 boys from 14 to 17, make a last desperate stand against the forces of the Church. The story, which is full of force and originality, is thus told in the concluding chapters. This is how they prepared for the attack. Clarence explains :—

"I start twelve immensely strong wires—naked, not insulated—from a big dynamo in the cave—dynamo with no brushes except a positive and a negative one——. The wires go out from the cave and fence in a circle of level ground a hundred yards in diameter; they make twelve independent fences, 10 feet apart—that is to say, twelve circles within circles—and their ends come into the cave again. The fences are fastened to heavy oaken posts, only 3 feet apart, and these posts are sunk 5 feet in the ground. The wires have no ground connection outside of the cave; a cavalry charge hurls itself against the fence; the moment they touch it they form a connection with the negative brush *through the ground*, and drop dead. In the centre of the inner circle, on a spacious platform 6 feet high, I've grouped a battery of thirteen gatling guns, and provided plenty of ammunition. The glass cylinder dynamite torpedoes are attended to. It's the prettiest garden that was ever planted. It's a belt 40 feet wide, and goes around the outer fence—distance between it and the fence 100 yards—kind of neutral ground, that space is. There isn't a single square yard of that whole belt but is equipped with a torpedo. We laid them on the surface of the ground, and sprinkled a layer of sand over them. It's an innocent-looking garden, but you let a man start in to hoe it once, and you'll see."

They proclaim the Republic, and the Church's knights arrive in force.

The big day arrived in time. At dawn the sentry on watch in the corral came into the cave and reported a moving black mass under the horizon, and a faint sound which he thought to be military music. Breakfast was just ready; we sat down and ate it.

This over, I made the boys a little speech, and then sent out a detail to man the battery, with Clarence in command of it.

The sun rose presently, and sent its unobstructed splendours over the land, and we saw a prodigious host moving slowly toward us, with the steady drift and aligned front of a wave of the sea. Nearer and nearer it came, and more and more sublimely imposing became its aspect; yes, all England was there apparently. Soon we could see the innumerable banners fluttering, and then the sun struck the sea of armour and set it all aflash. Yes, it was a fine sight; I hadn't ever seen anything to beat it,

At last we could make out details. All the front ranks, no telling how many acres deep, were horsemen—plumed knights in armour. Suddenly we heard the blare of trumpets; the slow walk burst into a gallop, and then—well, it was wonderful to see! Down swept that vast horseshoe wave—it approached the sand-belt—my breath stood still; nearer, nearer—the strip of green turf beyond the yellow belt grew narrow—narrower still—became a mere ribbon in front of the horses—then disappeared under their hoofs. Great Scott! Why, the whole front of that host shot into the sky with a thunder-crash, and became a whirling tempest of rags and fragments; and along the ground lay a thick wall of smoke that hid what was left of the multitude from our sight.

Time for the second step in the plan of campaign; I touched a button, and shook the bones of England loose from her spine.

In that explosion all our noble civilisation-factories went up in the air and disappeared from the earth. It was a pity, but it was necessary.

We could not afford to let the enemy turn our own weapons against us.

Now ensued one of the dullest quarter-hours I had ever endured. We waited in a silent solitude enclosed by our circles of wire, and by a circle of heavy smoke outside of these. We couldn't see over the wall of smoke, and we couldn't see through it. But at last it began to shred away lazily, and by the end of another quarter-hour the land was clear and our curiosity was enabled to satisfy itself. No living creature was in sight! We now perceived that additions had been made to our defences. The dynamite had dug a ditch more than a hundred feet wide, all around us, and cast up an embankment twenty-five feet high on both borders of it. As to the destruction of life, it was amazing. Moreover, it was beyond estimate. Of course we could not *count* the dead, because they did not exist as individuals, but merely as homogeneous protoplasm, with alloys of iron and buttons.

I picketed the great embankments thrown up around our lines by the dynamite explosion—merely a look-out of a couple of boys to announce the enemy when he should appear again.

Next, I sent an engineer and forty men to a point just beyond our lines on the south, to turn a mountain brook that was there, and bring it within our lines and under our command, arranging it in such a way that I could make instant use of it in an emergency. The forty men were divided into two shifts of twenty each, and were to relieve each other every two hours. In ten hours the work was accomplished.

As soon as it was good and dark, I shut off the current from all of the fences, and then groped my way out to the embankment bordering our side of the great dynamite ditch. I crept to the top of it and lay there, on the slant of the muck, to watch. But it was too dark to see anything.

I presently gave up looking, the night shut down so black, but I kept my ears strained to catch the least suspicious sound, for I judged I had only to wait and I shouldn't be disappointed. However, I had to wait a long time. At last I heard what you may call indistinct glimpses of sound—dulled metallic sound. I pricked up my ears, then, and held my breath, for this was the sort of thing I had been waiting for. I heard that metallic noise descending into the great ditch. It augmented fast, it spread all along, and it unmistakably furnished me this fact: an armed host was taking up its quarters in the ditch. Yes, these people were arranging a little surprise party for us. We could expect entertainment about dawn, possibly earlier.

I groped my way back to the corral now; I had seen enough. I went to the platform and signalled to turn the current on to the two inner fences. Then I went into the cave, and found everything satisfactory there—nobody awake but the working watch. I woke Clarence and told him the great ditch was filling up with men, and that I believed all the knights were coming for us in a body.

We crossed the corral and lay down together between the two inside fences. We started a whispered conversation, but suddenly Clarence broke off and said :—

"What is that? There beyond you a little piece—a dark something—a dull shape of some kind—against the second fence."

I gazed and he gazed. I said :—

"Could it be a man, Clarence?"

"No, I think not. If you notice, it looks a lit—why, it *is* a man!—leaning on the fence."

"I certainly believe it is; let us go and see."

We crept along on our hands and knees until we were pretty close, and then looked up. Yes, it was a man—a dim great figure in armour, standing erect, with both hands on the upper wire—and, of course, there was a smell of burning flesh. Poor fellow, dead as a door-nail, and never knew what hurt him. He stood there like a statue—no motion about him, except that his plumes swished about a little in the night wind. We rose up and looked in through the bars of his visor, but couldn't make out whether we knew him or not—features too dim and shadowed.

We heard muffled sounds approaching, and we sank down to the ground where we were. We made out another knight vaguely; he was coming very stealthily, and feeling his way. He was near enough now for us to see him put out a hand, find an upper wire, then bend and step under it and over the lower one. Now he arrived at the first knight—and started slightly when he discovered him. He stood a moment—no doubt wondering why the other didn't move on; then he said, in a low voice, "Why dreamest thou here, good Sir Mar——." Then he laid his hand on the corpse's shoulder and just uttered a little soft moan and sank down dead. Killed by a dead man, you see—killed by a dead friend, in fact. There was something awful about it.

These early birds came scattering along after each other, about one in every five minutes in our vicinity, during half an hour. They brought no armour of offence but their swords; as a rule they carried the sword ready in the hand, and put it forward and found the wires with it. We would now and then see a blue spark when the knight that caused it was so far away as to be invisible to us; but we knew what had happened, all the same, poor fellow: he had touched a charged wire with his sword and been elected. We had brief intervals of grim stillness, interrupted, with piteous regularity, by the clash made by the falling of an ironclad; and this sort of thing was going on, right along, and was very creepy, there in the dark and lonesomeness.

We concluded to make a tour between the inner fences. It was a curious trip. Everywhere dead men were lying outside the second fence—not plainly visible, but still visible; and we counted 15 of those pathetic statues—dead knights standing with their hands on the upper wire.

One thing seemed to be sufficiently demonstrated; our current was so tremendous that it killed before the victim could cry out. Pretty soon we detected a muffled and heavy sound, and next moment we guessed what it was. It was a surprise in force coming. I whispered Clarence to go and wake the army, and notify it to wait in silence in the cave for further orders. He was soon back, and we stood by the inner fence and watched the silent lightning do its awful work upon that swarming host. One could make out but little of detail; but he could note that a black mass was piling itself up beyond the second fence. That swelling bulk was dead men! Our camp was enclosed with a solid wall of the dead—a bulwark, a breastwork, of corpses, you may say. One terrible thing about this thing was the absence of human voices; there were no cheers, no war cries. Being intent upon a surprise, these men moved as noiselessly as they could; and always when the front rank was near enough to their goal to make it proper for them to begin to get a shout ready, of course they struck the fatal line and went down without testifying.

I sent a current through the third fence, now; and almost immediately through the fourth and fifth, so quickly were the gaps filled up. I believed the time was come now for my climax; I believed that the whole army was in our trap. Anyway, it was high time to find out. So I touched a button and set fifty electric suns aflame on the top of our precipice.

Laud, what a sight! We were enclosed in three walls of dead men! All the other fences were pretty nearly filled with the living, who were stealthy working their way forward through the wires. The sudden glare paralysed this host—petrified them, you may say, with astonishment; there was just one instant for me to

utilise their immobility in, and I didn't lose the chance. You see, in another instant they would have recovered their faculties, then they'd have burst into a cheer and made a rush, and my wires would have gone down before it; but that lost instant lost them their opportunity for ever; while even that slight fragment of time was still unspent, I shot the current through all the fences and struck the whole host dead in their tracks! *There* was a groan you could *hear!* It voiced the death pang of eleven thousand men. It swelled out on the night with awful pathos.

A glance showed that the rest of the enemy—perhaps ten thousand strong—were between us and the encircling ditch, and pressing forward to the assault. Consequently we had them *all!* and had them past help. Time for the last act of the tragedy. I fired the three appointed revolver shots, which meant—

"Turn on the water!"

There was a sudden rush and roar, and in a minute the mountain brook was raging through the big ditch, and creating a river a hundred feet wide and 25 deep.

"Stand to your guns, men! Open fire!"

The thirteen Gatlings began to vomit death into the fated ten thousand. They halted, they stood their ground a moment against that withering deluge of fire, then they broke, faced about, and swept toward the ditch like chaff before a gale. A full fourth part of their force never reached the top of the lofty embankment; the three-fourths reached it and plunged over—to death by drowning.

Within ten short minutes after we had opened fire, armed resistance was totally annihilated, the campaign was ended, we fifty-four were masters of England! Twenty-five thousand men lay dead around us.

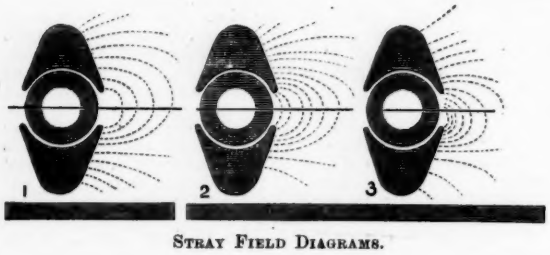
PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

MARCH 20TH, 1890.

Continuation of discussion on Mr. Swinburne's paper, "The Theory of Armature Reaction in Dynamos and Motors," and on Mr. Esson's paper, "Some Points in Dynamo and Motor Design." (Authorised Abstract.)

Mr. A. P. TROTTER disagreed with Mr. Esson's statement on slip 2, as to the inutility of, and the difficulties attending, calculations of the stray field, and said that since Prof. Forbes gave his



STRAY FIELD DIAGRAMS.

three lectures in 1886 the work has been comparatively simple, and constituted part of the drawing office routine at Halifax. Speaking of differences in the quality of iron, he said forged bars

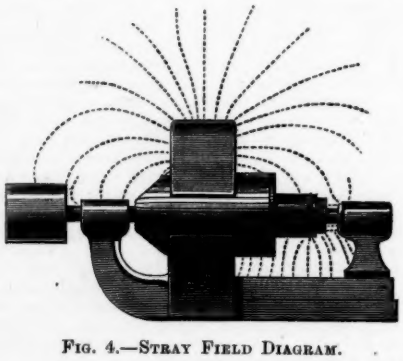


FIG. 4.—STRAY FIELD DIAGRAM.

could be depended on, but charcoal iron was not so reliable. Any doubt as to the behaviour of iron, in his opinion, renders it all the more necessary to calculate the waste field, so that only one unknown factor may be present. This predetermination is most important when any departure from ordinary designs is made, for in such cases one cannot be guided by previous experiment. As an instance of the accuracy attainable in these calculations, he said that in Messrs. Goolden & Co.'s M type dynamo, where the leakage amounts to 60 per cent., Mr. Ravenshaw predicted this to within 1 per cent. Mr. Trotter also exhibited some interesting diagrams plotted by a novel method on the machine itself, which show the directions of the waste field under various conditions of armature and field excitation; on one of these the distorting effect of a large armature current could be easily seen. From such diagrams, 1, 2, 3 and 4, combined with Prof. Forbes's formulæ, the speaker thinks a line can be determined, in terms of whose length the magnetic resistance between any two parts considered may be stated.

Mr. VIGNOLES confirmed Mr. Trotter's remarks about the calculations of waste field by Mr. Ravenshaw. He also pointed out that Mr. Esson used the word "saturation" in various senses, and he thought it desirable that a distinct meaning should be given to the word by definition.

Mr. S. JOYCE, speaking of Mr. Esson's rule for rise of temperature, said such rules could only give the temperature at the surface, and not that of the interior, which was probably much greater. As the difference in temperature between the inside and outside of the winding varies as the square of the depth, this difference may become excessive in large machines. The expression for this difference, on the assumption that the inside and outside surface are parallel planes, was given as $\frac{h\,D^2}{2\,K}$, where h = C.G.S. heat units generated per cubic centimetre, D = depth of winding, and K its thermal conductivity. For cylindrical surfaces of ordinary dimensions the difference is about 3 per cent. less. The quantity K may be calculated from the equation $K = \frac{z\,d}{2\,\delta}$, where z is the thermal conductivity of the insulating material, d the diameter of the covered wire, and δ the radial depth of insulation. The speaker said the value of z given for cotton by Prof. Everett was ·00001, by Prof. Forbes ·00003; but he himself found it ten times the latter, viz., ·0003. His own experiments on "emissivity" of varnished cotton gave the number ·0005, whereas Macfarlane's result for blackened copper was ·0003. He had also found that by leaving about 10 per cent. of armature cores exposed, the difference of temperature between the inside and outside of the winding was reduced to a quarter that which exist when the whole surface is covered with wire.

Mr. J. D. F. ANDREWS said the specimens of armature winding exhibited by Mr. Crompton were very interesting, but thought the heating difficulty could be got over in a simpler way. In one dynamo he had constructed, with bars $\frac{5}{8}$" × $\frac{3}{8}$", the heating was immense when running at no load. On cutting away the pole-pieces, tangential with the armature, the rise of temperature was 100° F., and by putting the bars on edge this was reduced to 30°. After rounding off the top corners of the bars there was no heating.

Mr. STUART A. RUSSELL, referring to Mr. Esson's curve for maximum output (fig. 21), said he believed this was obtained on the assumption that the depth of winding inside the armature was equal to the depth outside. If the difference between these depths be taken into account, then, in ordinary cylinder armatures, instead of the core being about 4 times the depth of the winding, it becomes 5¼ times. As regards size and output, the speaker said he had found the rule.—Total induction ∝ (watts per revolution)$^{\frac{3}{4}}$ very convenient, and that it nearly agreed with that given by Mr. Snell. Referring to the difficulty in compounding slow speed machines, Mr. Russell said, one cause arises from the want of proportionality between the additional ampère turns on the magnets and the back ampère turns on the armature. In the former they are proportional to the currents simply, whilst in the latter they are proportional to the current multiplied by the angle of lead. Hence, if the compensating turns are made right for full load then the middle of the curve will be too high. Concerning the design of motors, the speaker said he agreed with the authors of the papers, but the startling nature of the curves shown by Prof. Ayrton had led him to make experiments on the subject. In these a double horseshoe Gramme machine was used with the magnets and armature current decreased and increased 40 per cent. respectively, so as to obtain a relatively powerful armature. In addition to taking volts and ampères the field was measured by the ballistic method. The first set of experiments were made with brushes of the ordinary thickness (1¼ segments). The results showed that with no lead $V - C_R$, as a motor, was about 8 per cent. greater than $V + C_R$ as a generator, whilst with lead and trail of 18° the difference was 4 per cent. This difference, he believes, is accounted for by self-induction, for there was very little change in the field induction. In a second set of experiments two brushes, in parallel, arranged so as to short-circuit four sections, were used; the difference between $V - C_R$ and $V + C_R$ amounted to 75 per cent. of the mean, but it was also noticed that the change in the field only amounted to about 30 per cent., and that $V - C_R$, as a motor, was greater than the E.M.F. corresponding to the induction used. From these observations Mr. Russell concludes that the E.M.F. of a motor may be made greater than that of a dynamo by short-circuiting a number of sections, thereby increasing the armature induction, but that no advantage is gained because the result is just the same whether the greater induction is produced by field magnet windings or by

coils short-circuited by the armature brushes. His experience with motors having thick brushes did not agree with Mr. Snell's, for, in tramcar work, he (the speaker) got the best results with brushes of ordinary thickness.

Mr. WYLES said no doubt need exist as to the possibility of making smooth commutator machines for high voltages, and that the difficulties experienced arose from the great differences in the insulation of similar machines. The insulation of some may be excellent, whereas that of others wound with equal care is comparatively bad. These differences are met with in machines of E.M.Fs. as low as 200 volts.

Mr. GEIPEL asked whether cross-induction could not be reduced by cutting the pole-pieces in fig. 3 of Mr. Swinburne's paper in two parts at E.E., and by laminating the magnets in a direction perpendicular to that of the cross lines. Referring to Mr. Esson's temperature limit of 75° C., he enquired whether any modification would be made for machines intended for tropical climates.

Dr. S. P. THOMPSON, in a communication read by Mr. Kapp, said a good approximation to the back ampère-turns was got by multiplying the number of conductors between the pole corners by half the armature current, and that he agreed with Mr. Swinburne as to the usual position of the brushes. He complained of Mr. Swinburne's use of "ergs" in measuring magnetic potential, and asked why in naming the pole corners he had reversed the ordinary usage. He also enquired why Mr. Esson takes the load carried by armatures as proportional to the depth of armature core. Speaking of "leakage coefficients," he pointed out that this is not constant, even for machines of the same type, but is less for the larger machines. Referring to the statement by Mr. Esson that the induction in large armatures should be less than in small ones, Prof. Thompson asked whether this was true both of disc and wire cores. As regards smooth commutator machines for high volts, he said Messrs. Paterson and Cooper had made such machines successfully for some time, and that in Ball's so-called "unipolar dynamo" was an instance of a smooth commutator machine working 80 arcs in series.

Mr. MACWHIRTER objected to Mr. Swinburne's use of the symbol, Ω, for magnetic potential, for this is the recognised symbol for megohm. He also said that some system of symbols was greatly needed, and suggested that the Nomenclature Committee appointed by the Society some five years ago should present an interim report. Speaking of the magnetic pull on armatures of single magnet machines, he said his firm found the the method of placing the armature eccentrically very effective. Their motors were always made on the same lines as dynamos, for they found that machines with light fields always sparked.

The PRESIDENT expressed his great appreciation of both papers under discussion, but owing to the lateness of the hour would only criticise a few points in Mr. Swinburne's. The rule given for lead of brushes seemed to him hardly correct, for in machines with which he was acquainted the lead was always less than half the angle between the pole corners. There were two points to which he wished to direct Mr. Swinburne's attention, viz., the effect of having a great or a smaller number of commutator bars, and of thick or thin brushes. Speaking of the term "magnetic resistance," he said there were two reasons why he did not use it; first, the generally accepted idea of *resistance* was such that $(flux)^2 \times resistance$ was a rate of doing work, so-called "magnetic resistance" did not satisfy this condition. Secondly, "co-efficient of resistance" are generally constant and express properties of the material or medium, "Magnetic resistance," however, is by no means constant, and he thought its use open to the same objections as "resistance of an electric arc," an expression which was very misleading.

Mr. SWINBURNE, in reply, said the main subject of his paper had not been discussed. Its object was to show how to obtain an expression for the lead of the brushes in terms of the polar angle and thus determine the back induction before the machine was made. This being of much greater importance in regard to large machines, the greater part of his paper referred to such machines, but, unfortunately, many of the speakers assumed it applicable to small machines and discussed it accordingly. Prof. Ayrton, he said, had accused him of using "magnetic potential" where "difference of magnetic potential" was meant. This he denied, and pointed out that he had been careful to speak of differences of magnetic potential. Referring to "magnetic lag," he said the time lag discovered by Prof. Ewing had no connection with the once supposed lag to which the lead of the brushes was wrongly attributed. As regards the results of experiments on machines run as generators and motors by Prof. Ayrton; he pointed out that in those experiments where the E.M.F. became negative with a large armature current, the generator became a motor and the brushes were then in the wrong position. He also contended that, in all cases where the E.M.F. of a motor increased with increase of armature current, the brushes were not in the proper position. He believed Mr. Esson's results on the Bürgin machine was due to the same cause, for in this machine, unless made specially as a motor, the brushes could not be put back far enough to run sparklessly. Probably Mr. Esson had been misled by not being aware that the commutator connections are skewed. Replying to the criticisms on his use of "ergs" in measuring magnetic potential, he said Sir W. Thomson was the first to introduce it, and as it had been used by Maxwell and others, he thought he might use it too. His objections to "magnetic resistance" are: First, that the term has no definite meaning; second, that the analogy whence it is derived is wrong; and, third, if used it is liable to lead to error as has already been the case with regard to transformers. Magnetism, he said, was analogous to electrostatics, and permeability to specific inductive capacity, not to conductivity, as the advocates of magnetic resistance would have us suppose. Referring to Mr. Kapp's remarks on enlarging dynamo to scale, he said that the impossibility of doing so successfully had been pointed out seven years ago by Dr. Hopkinson, who about that time got three times the output at present obtained by Mr. Kapp and others from machines of the same weight. In his opinion, four-pole drum machines would be used in the future for large outputs. Speaking of the Admiralty temperature test, Mr. Swinburne said it was comparatively useless, for it failed to pick out the best machines. To do this the temperature of the conductors should be ascertained, and this could be done by taking the resistance of the armature, in spite of Mr. Mordey's bad joints. He was sorry to learn that Mr. Mordey had not been able to make a shunt brush machine work successfully, for he himself had done so, and the inventor of the machine approved of the arrangement. As regards the position of the brushes relative to the pole corners he pointed out that Dr. Thompson's observations agreed with his own, and not with those of the president. In answer to the president's enquiry why he did not integrate to infinity on slip 5, he said the integration had only been given as a rough approximation, near enough the truth to show that a comparatively weak field is required to reverse the current in the armature sections of direct current machines. If alternating machines were under consideration, the treatment of the integration would be much more important.

Mr. ESSON in his reply said Mr. Kapp's method of overcoming side pull had the disadvantage of not allowing the coils to be slipped over the poles, and that even if adopted the distribution of the field was not the same near the top brushes as near the bottom ones; the arrangement in Fig. 9 gave a much more uniform field. He could not understand how Mr. Kapp saw any "dodge" in designing armatures to give large outputs, for the magnets were designed in accordance with the armatures with which they had to work. Neither could he understand Mr. Ravenshaw's remarks about the loading of armatures. In his opinion the machines of a set could not be all in the same condition as regards balance of field, and he thought all Mr. Ravenshaw's dynamos were underloaded. He was glad to see that Prof. Ayrton's remarks respecting the number of ampère-turns required for compounding agreed with his own statement on the subject. Speaking of the Admiralty test, he said the method of making the test was to heat the thermometer 30° F. above the surrounding air before applying it to the armature, and then noting its rate of rise or fall when so applied. Machines giving a rise of 40° were accepted subject to a fine. He was now of opinion that the rise allowed by the Admiralty was quite enough for machines which had to work in hot engine rooms. Referring to Mr. Crompton's armature conductors he said he had used stranded wire for the same purpose, but the section of his subdivided conductor was round and not made rectangular as in Mr. Crompton's. He would have been glad to learn something about the collection of large currents, for this seemed to be one of the most difficult problems at present. On the subject of motor construction, Mr. Esson said Prof. Ayrton's curves showed that it was difficult to prove either point conclusively; however he thought he could see where Prof. Ayrton and Perry had been led into error. In their paper on electro-motors, &c., the output of a machine is given as $w \propto (L\, l \cos a \mp l^2 \sin a)$ where L and l are the weights of the magnets and armature respectively, and a the angle of lead. In order that this may be a maximum for a dynamo (where the negative sign is to be taken) L must be large compared with l, but in dealing with motors the professors said the + sign should be used, and this led to the large armature view. Mr. Esson, however, contended that the negative sign is the one to be taken both for dynamos and motors. The positive sign, he said, leads to bad machines which always spark.

"Alternating *v.* Continuous Currents in Relation to the Human Body." By H. NEWMAN LAWRENCE, Member, and ARTHUR HARRIES, M.D., read March 27th, 1890.

Much attention has already been drawn, both in England and America, but especially in the latter country, to the dangers to which workmen and others are exposed when handling and working with wires, dynamos, and other apparatus connected with the generation and supply of electric currents for light and power.

A lively controversy regarding the relative safety of continuous or alternating currents has resulted; but little, if anything, has been done to throw direct light upon the matter, and great difficulty is therefore experienced by disinterested persons in arriving at a satisfactory conclusion.

It is with great diffidence that we venture to offer this short paper on the subject, as the experiments and observations upon which our contribution is based were not specially undertaken with the object of throwing light upon it. They form part of a series of data connected with investigations upon which we are engaged with the hope of solving some of the physiological problems occurring in the course of our electro-therapeutic work at the Institute of Medical Electricity.

The results obtained from some of our experiments (hereinafter given in detail) led us to note how strongly they bore on the question now before us. We therefore, after verifying them by repetition, thought it well to invite discussion upon them, and now offer them for your consideration, with full consciousness

of their imperfection. They differ from the experiments of D'Arsonval, Harold P. Browne, and others, in the important point that they deal, not with the bodies of rabbits, dogs, and horses, or other animals (from which conclusions regarding human life have to be evolved), but directly with the human body.

We do not in any way propose to touch upon the question of the manner in which accidents with electric wires, &c., occur, or how they may be prevented. It would be manifestly beyond our province to do so. Our object is rather to compare the physiological action of the two forms of current *after the contact*, accidental or otherwise, has been made, and to arrive at some conclusion as to the danger-ratio which one form of current may bear to the other under such conditions.

As may already have been gleaned, our experiments have not been made with the powerful currents dealt with in electric lighting and distribution of power. We have used small currents, for the most part at low E.M.F., and have directed our attention to—

1. The determination of the resistance of the human body and skin to the passage of currents under certain conditions; and,

2. A comparison of the sensations produced in the human body by passage of the two forms of current.

1. With regard to the resistance of the human body and skin. In his Lumleian lectures delivered before the Royal College of Physicians in April, 1886, Dr. W. H. Stone gave some very useful information. His experiments appear to have been carried out with care, and the results, therefore, are reliable. In the course of many similar experiments we find no reason to differ in the main from the figures he has arrived at, and we quote those that refer to our immediate subject in the following table:—

TABLE A.

	Resistance, foot to foot.	Resistance, foot to hand.
Mr. T.	945 ohms	1,320 ohms
Mr. S.	930 „	1,027 „
Hungarian giant	930 „	1,032 „

There is, however, this important fact to be taken into account, when considering the bearing which these figures have on the present question, viz., that Dr. Stone, having a direct therapeutic object in view, was dealing (as far as he could) with the internal resistance of the body, and not with its total resistance as represented by that of internal tissues and skin in its normal insulating condition.

Further, Dr. Stone's experiments were scarcely typical of results to be expected from either purely continuous or purely alternating currents, for in his lecture he says, with reference to the experiments quoted in Table A, that he had in "circuit a Wheatstone bridge of a rather particular form, a commutating key so as to send the current in opposite directions, &c."

Some experiments conducted by Mr. Wm. Lant Carpenter, however, are more in accordance with the conditions which this paper is intended to illustrate, as they enable us to form some clear idea of the nature of the current actually used.

The results of these experiments, published in August, September and October, 1883, in *Health*, are shown in

TABLE B.—CONTINUOUS CURRENTS.

	Resistance from foot to foot in ohms.		Resistance from foot to foot in ohms.
Dry skin	— min. 10,300	Salt and water ...	30 min. 1,400
Salt and water ...	1 „ 4,300	„ „ ...	35 „ 1,290
„ „ ...	5 „ 2,500	„ „ ...	40 „ 1,250
„ „ ...	7 „ 2,100	„ „ ...	45 „ 1,230
„ „ ...	10 „ 1,900	„ „ ...	50 „ 1,200
„ „ ...	15 „ 1,720	„ „ ...	60 „ 1,190
„ „ ...	20 „ 1,540		to 1,200
„ „ ...	25 „ 1,470		

Our own experiments have been made with the skin *normally dry* and *moist*, and we have selected measurements taken from hand to hand, as the hands are the parts most likely to come into contact with wires and other conductors.

The first series of readings are those of resistance to continuous current. They were taken by the ordinary Wheatstone bridge method with a mirror galvanometer. Tin electrodes, each of 50 sq. cm. area, were used, the extended palms being placed upon the electrodes.

The results are shown in Table C.

In estimating the measurement of resistance to the continuous current we must remember that, as the result of the almost instantaneous congestion which follows the closing of the circuit, *resistance is to a certain extent diminished.*

Very shortly this is succeeded by polarisation, and by the conditions which accompany the conversion of the body into a secondary battery, and there is consequently a considerable increase in resistance when the passage of current is continued for an appreciable time.

TABLE C.—RESISTANCE TO CONTINUOUS CURRENTS.

Subject.	Age about.	Dry.	Moist with distilled water.	Moist with salt water.
		Ohms.	Ohms.	Ohms.
1	35 years	39,000	19,700	9,170
2	22 „	49,000	7,700	5,900
3	35 „	41,400	23,000	11,000
4	38 „	40,000	11,500	5,900
5	35 „	50,000	9,500	5,000
6	40 „	45,000	30,400	26,400
7	21 „	19,000	7,600	6,700
8	22 „	27,000	25,400	12,000
9	26 „	31,000	7,000	6,500
10	24 „	40,000	10,700	7,000

On the other hand, the passage of alternating currents is accompanied by a diminishing resistance from the outset, for the early physiological congestion is followed neither by polarisation nor by the electrolytic action which it is usual to expect when the continuous current is used.

Table D shows the resistance to alternating currents of the same ten people taken with the same electrodes on the same occasion as those referred to in Table C.

TABLE D.—ALTERNATING CURRENTS.

Subject.	Dry.	Moist with Distilled Water.	Moist with Salt Water.
	Ohms.	Ohms.	Ohms.
1	2,900	2,500	1,500
2	10,400	1,800	1,200
3	5,500	1,600	1,600
4	2,500	2,200	1,200
5	5,400	1,600	1,500
6	2,600	1,700	1,300
7	1,400	1,450	1,250
8	2,350	1,500	1,400
9	3,500	1,500	1,600
10	5,000	1,375	1,500

Tables C and D are fairly comparable as regards the same individuals, though the maximal differences are strongly marked.

Dr. Stone, in his lecture above referred to, mentioned a very important fact which since appears to have been overlooked, viz., that (under the conditions he adopted) the resistance of the human body was only about half as great for alternating currents as for the continuous current. This statement we have never seen questioned, and our own experiments show that under conditions more assimilating to those likely to occur in practical work, the proportion is considerably greater. Table D shows wide variations in the resistance of the individuals tested, as well as other peculiarities which are no doubt partly due to errors of observation, but more largely due to physiological conditions which are scarcely relevant to this paper; but the tremendous difference between the resistance to alternating currents and the resistance to the continuous current is clearly and definitely marked, and justifies us in drawing certain conclusions therefrom. We find the—

	Ohms.
Average resistance to the continuous current, moist with salt and water,	9,557
alternating „ „ „ „	1,405
continuous „ „ „ distilled water,	15,250
alternating „ „ „ „	1,722
continuous „ dry	38,140
alternating „ „	4,155

When this condition of things became apparent we thought it well to confirm our experiments by repeating them as far as possible under conditions such as would occur in actual working.

The results of this set of control experiments we give in Table E. The ten persons tested were chosen so as to be, as far as possible, representatives of those likely to come in contact with electric light and power wires and other conductors. Five were workmen with hands hardened, and rendered by toil, as far as may be, insensitive to electric currents. The other five men were accustomed to brain work, and may be taken as representing the occupiers of houses likely to use the electric light, and occasionally to come into contact with the leads, terminals, lamps, &c., of house installations.

The electrodes used were of plain metal, and could be grasped in the hand, and so may be taken to represent the metal about a dynamo, or a bare wire or other conductor, which might be grasped accidentally by a workman occupied about a lighting or power station, or by a gentleman investigating some electrical irregularity in his own house.

The continuous current tests were made with a Wheatstone bridge of Post Office pattern, and a mirror galvanometer. The alternating currents tests were made with one of Kohlrausch's rheometers, in which the balance is observed through a telephone. The alternating currents obtained from the induction coil of the instrument had a periodic frequency of about 300 per second.

The dry readings were taken with normally dry hands. The moist readings were taken after the hands had been dipped into ordinary tap water.

Table E.

Subject.	Resistance in Ohms.			
	Dry hands.		Moistened hands.	
	C.C.	A.C.	C.C.	A.C.
1	36,000	2,200	25,000	1,450
2	17,000	1,850	9,000	1,400
3	7,000	1,800	6,400	1,600
4	12,000	1,400	5,900	1,275
5	18,900	1,600	14,700	1,450
6	8,400	1,450	3,900	1,200
7	10,450	1,000	7,500	1,300
8	8,500	1,500	7,300	1,450
9	14,300	2,000	10,900	1,600
10	12,200	1,900	6,900	1,650
Average... ...	14,475	1,740	9,750	1,437

These results indicate that the resistance of the human body to continuous current is 6·8 *times* greater than it is to alternating currents when the skin is moistened, and 8·3 times greater when the skin is in its normal condition and not moistened by artificial means.

Starting with the statement of Dr. Stone that when the skin has been well soaked with a conducting fluid, and electrodes of large area are used, so that little, if any, more than the internal resistance of the body comes under observation, the resistance to the continuous current is nearly double that to alternating currents (Electrical Review, May 7th, 1886, page 417), we find that the ratio increases conversely with the moisture of the skin, till in the normal condition we reach the maximum of 9·1 for contact of small area, and 8·3 for contact obtained under ordinary working conditions.

We now come to the second part of our subject, viz.: A comparison of the sensations produced in the body by the passage of the two forms of current.

The sensitiveness of persons to the continuous current varies very much, quite independently of variation of resistance. But we find that most people (and we have tested some hundreds) can bear without discomfort the passage of 10 milliampères for a short time, and therefore for the purposes of this paper we will consider that amount of current-strength as the maximum which may be passed through the body without producing unpleasant sensations.

With alternating currents, however, a very different state of things is disclosed; for having in the course of our therapeutic work found the great need for accurately measuring the alternating currents from induction coils, we obtained from Germany (after failing to find a suitable instrument of English make) a galvanometer recording milliampères of alternating currents, and on putting it in circuit with a patient, were surprised to note that before the needle indicated the passage of a single milliampère the patient complained that the current was too strong, and practically unbearable.

This, of course, led to further investigation, with the result that, though we tested a large number of persons of varied age and of both sexes, we found only a few who could bear with comfort the passage of one milliampère of alternating currents.

Table F shows the result of sensation tests made upon the ten subjects above referred to.

Table F.—Sensation Tests.

Subject.	Without Discomfort.		Muscular fixation.
	C.C.	A.C.	A.C.
	Ma.	Ma.	Ma.
1	10·0	2·0	4·5
2	10·0	2·0	3·0
3	10·0	2·5	3·75
4	10·0	1·0	2·75
5	10·0	1·0	2·0
6	10·0	2·0	3·25
7	10·0	2·5	6·0
8	10·0	2·0	4·5
9	10·0	1·0	2·25
10	10·0	1·0	4·0
Average ...	10 0	1·7	3·6

[*Experimental sensation tests were here shown.*]

So far we seem to be justified in putting the limit for alternating currents at two milliampères, and we wish it to be understood that any advance upon this limit means extreme discomfort. Beyond that point violent muscular contraction, rendering relaxation of grasp first difficult, and then impossible, produces distinct pain, which agitates the whole body.

We can therefore confidently state that, as far as sensations are concerned, the human body can bear with ease at least five times as much of continuous-current strength as of alternating-current strength. When this fact is taken in connection with the great difference in the resistance offered by the body to the two forms of current, it leads to the conclusion that the danger of unpleasant consequences, and possibly (if not probably) of loss of life, when currents of equal voltage are handled, is 34 times (6·8 × 5) greater with moist hands, and 41·5 times (8·3 × 5) greater with dry hands, when alternating currents are used than when the continuous current is employed. These figures we will adopt as representing the *danger ratio*.

As a practical example of this conclusion we may take the Board of Trade limit of pressure at which currents may enter houses, viz., 200 volts, and assume that a man having the average resistance taken from Table E handles naked wires within the house.

With the continuous current (dry hands) $C = \frac{200}{14,475} = 13{\cdot}5$ milliampères.

He thus receives only 13·5 milliampères, which is little more than, as shown above, he can take with perfect impunity.

With alternating currents (dry hands) $C = \frac{200}{1,740} = 115$ milliampères.

He thus receives 57 *times more current* than he can bear without discomfort, and the danger of physiological shock is correspondingly increased.

It may be objected that all this has little relevancy when large currents, of either kind at high potentials, have to be dealt with; but we would submit that what we have proved to be the case with small currents and low potentials may be fairly taken to be intensified as the current strength and E.M.F. increase. There is at present no reason to suppose that the ratio of resistance diminishes, or that of the sensations becomes lessened, though it may possibly happen that with increased current strength or higher potential the absolute resistance may vary.

What the minimum current of either kind which will destroy human life may be, we are not in a position to say; though D'Arsonval, in his report on electro-physiology made before the International Congress of Electricians held at Paris, 1889, says, referring to his experiments on rabbits, guinea pigs, and dogs:—

"With a machine of 8,000 volts a momentary closing of the current caused the animal (a rabbit) to make a prodigious leap, but did not cause death immediately; a second application was necessary."

"An alternating Gramme machine only causes death above 120 volts mean potential."

These statements are not very clear, but we gather therefrom that while a continuous current machine having an E.M.F. of 8,000 volts did *not* instantly kill a rabbit, yet an alternating current machine having a mean potential of 120 volts did. We feel sure that no hard-and-fast lines can be laid down on the subject. *Individual resistance and individual sensitiveness vary so much and so unexpectedly* that a current which might be taken with impunity by one person might be more than enough to kill another.

With regard to danger ratio, D'Arsonval seems to more than bear out the conclusions that we have arrived at, though he gives no information as to the current strength used.

Independently of the kind of current used, the character of the contact made, the surface area of the body involved, and the suddenness of closing or opening the circuit must each and all play an important part in the result.

Shock varies with the form of current employed: thus with continuous current only a "make" initial shock is possible, while with alternating currents the initial shock may be either a "make" or a "break" shock.

As "break" shock is admitted to be the more marked of the two, independently of the steady diminution of resistance to alternating current, it is probable that the effects of an initial shock with alternating currents of similar strength may be more disastrous than that with continuous current.

Discussion.

Prof. Forbes said that although the comparisons of the effects of alternating and continuous currents were very interesting, the tests made and the results obtained had little bearing on the practical question of safety in the use of electricity for lighting and power purposes, for the conclusions arrived at in the paper are not in accord with actual experience. He was willing to admit that he could not bear so many volts alternating as continuous, but the difference was comparatively small, certainly nothing like so great as the authors would have him believe. The sensations, he said, depend not on the mean current but on the maximum value of the current or volts; and in the case of an induction coil the volts on break were immensely greater (20 to 50 times) than the maximum occurring in a well designed alternator, which would send the same mean current through the body as that indicated by the measuring instrument used.

Mr. Kapp concurred in Prof. Forbes's views as to the great difference existing between the conditions under which the experiments were made and those occurring in practice as regards alternating currents. From experiments he had tried himself, he found he could bear 100 volts continuous with about the same discomfort as 40 volts alternating.

Major Cardew agreed with Prof. Forbes's statement about the much greater maxima obtained with induction coils than with alternating machines, and said that great differences exist in the shocks received from different machines, even when the measured volts were the same. For example, shocks received from old Wilde machines were very severe, even when the volts were small; he had known a man to be nearly killed by a 300 volt machine of

that type, whilst from a modern alternator 100 volts may be taken without great discomfort. Speaking of resistance tests in Table E, he remarked on the great differences in the resistance of individuals to alternating and continuous currents, and on the disproportionality between them; these differences he believed due to polarisation of the electrolytes in the body. As regards sensations, he had reason to think that the effect of a given current depends on the volts employed to send the current. Referring to the Board of Trade Regulations, he informed the authors that permission to use 200 volts alternating on consumers circuits had never been granted.

Dr. STEVENSON agreed with the last speaker as to the current from a large battery producing more powerful sensations than an equal current from a smaller number of cells.

Mr. SAYERS thought sensation depends greatly on the shape of the E.M.F. curve and on the frequency of alternation.

Mr. WYLES said he once saw a man come into contact with a Brush 35-lighter; fortunately he fell away from the machine, and the only after effect was a pain across the chest.

Mr. E. T. CARTER asked whether the resistances to continuous currents were all obtained with the same current strength or whether various strengths were used in each case; for if there was polarisation, resistance would vary with current. He also enquired if the effects of purely transient currents, such as discharges from cables, and of electrostatic capacity, had been investigated, and asked what was the effect of alternating currents of frequencies less than 300 per second.

Mr. CROMPTON said he had recently tested the resistances of individuals by Evershed's ohmmeter, 100 volts being used in all cases. As a rule he found the resistance to fall from 30,000 or 40,000 to 25,000 by continued application, and in some cases 10,000 or 11,000 ohms were indicated. Children usually gave 8,000 to 10,000. One person whose wrist had recently been subjected to a surgical operation, gave a resistance of 25,000 from hand to hand, but on placing one electrode on the part operated on, the resistance fell to 14,000. The sensation effects varied greatly in different individuals, for some whose resistances were 30,000, experienced much greater discomfort than children with 10,000 ohms resistance. As to alternating currents, he believed that there was a general consensus of opinion that only about half as many alternating as direct volts could be borne. Some time ago he, in conjunction with Col. Armstrong, had made experiments to see what current one could bear, and they found that at 15 milliampères the skin below the electrodes became hot, whilst at 35 milliampères the skin was scorched in a few seconds.

Mr. F. H. NALDER suggested that the differences between the resistances with wet and dry hands might be due to surface leakage.

Mr. JOYCE said that even if we admit the difference in the E.M.F. curves of induction coils and alternators in producing sensations, as pointed out by Prof. Forbes, yet from Table E, one can see that there is a great difference between the resistances of the body to alternating and continuous currents. This of itself means a serious difference in the "danger-ratio."

Mr. W. H. PREECE believed there had been more nonsense talked about this subject, particularly on the other side of the Atlantic, than on any other with which he was acquainted, and they were indebted to the authors for clearing the ground a little. He himself had had the misfortune to receive the discharge from a Leyden jar and to be transfixed to a 2,000 volt Brush machine. He was also in the habit of receiving shocks from continuous currents of about 25 milliampères without experiencing as much unpleasantness as he had just felt with a current of 2 milliampères from the induction coil. This led him to enquire whether the instrument used to measure the latter current was accurate. Quite recently he had received an account of an accident whereby a man was subjected to a shock from a 1,200 volt circuit; his fingers were burned, and he was rendered insensible for ten minutes. Speaking of the so-called "dangers of electricity," he said the difficulty was to kill, rather than to prevent being killed, and that the question was not one of high or low potentials or alternating *v.* continuous currents, but of overhead *v.* underground mains and bad or good workmanship and insulation. In his opinion it should be impossible for anyone to accidentally come into contact with house circuits.

Dr. HARRIES said he had anticipated more discussion on the physiological points raised. Referring to Prof. Forbes's views, he remarked that the high voltage on breaks means little if the resistance be high. In reply to Major Cardew, he said the differences in resistance depend entirely on the normal state of the skin, and that polarisation does not play an important part, for in the continuous current experiments the contacts were instantaneous. As regards the effect of frequency, he stated that the greater the frequency the less unpleasant a given current becomes. Mr. Crompton's results in the main confirmed their own, but had thrown doubt on the polarisation effect. However, Dr. Stone had shown that it existed, and the first fall of resistance is accounted for by the congestion of the part touched.

Replying to the electrical points, Mr. LAWRENCE said the frequency of the alternating currents was about the same in all the experiments, and that from greater frequencies he would expect less effect. As to the accuracy of the milliampèremeter, he said he would be glad to have it tested by anyone interested. They themselves had had it tried by an experienced firm, who reported it to be within 5 per cent.

Mr. ALEX. SIEMENS (who was in the chair), in proposing a vote of thanks to the authors, said they had heard a great deal about the dangers of electricity but nothing about its beneficial applications. He himself had experienced its pain alleviating properties in the case of teeth extraction. The positive terminal of a battery was held in the hand and the negative attached to the forceps, and the pain was very slight compared to that experienced in the ordinary methods of extraction. The effect he believed due to the nerve being cauterised by the current, and he suggested to medical men the question, whether some such methods could be adopted with advantage in amputations and other surgical operations.

Physical Society.—March 21st, 1890.

Prof. W. E. AYRTON, F.R.S., President, in the chair.

Mr. A. E. Childs was elected a member of the Society.

The following communications were read: "The Villari Critical Points in Nickel and Iron," by HERBERT TOMLINSON, F.R.S. Villari has shown that the permeability of iron is increased by longitudinal traction provided the magnetising force does not exceed a certain limit, but beyond this limit traction produces a decrease of permeability. The value of the force for which traction produces no change in the permeability is known as the Villari critical point. As far as the author is aware no previous observer has found a similar critical point for nickel, but by confining his attention to *temporary* magnetisation he has detected such a point with comparative ease. He has also examined the variation of the Villari critical points in iron and nickel with change of load and has investigated the influence of permanent strain on these points. The experiments were made by the ballistic method, using wires about 400 diameters long. In each set of observations the permeability was obtained with various loads, the magnetising force being kept the same, and with each load the circuit was closed and opened until the swings on make and break were equal; this swing was taken as a measure of the induction under the given load. Several diagrams accompany the paper, in which load and percentage change of permeability are plotted, regard being had to sign. The author finds that for annealed unstrained iron the critical value of the force decreases as the load increases, and that the Villari point is much lower for *temporary* than for *total* magnetisation. With a load of 4·7 kilos on a 1 mm. wire, the value of the force giving the temporary point was 2·8 C.G.S. units. He also found that for a given magnetising force there are generally two loads which have no effect on the temporary magnetisation. With unstrained nickel the critical value of the force is much greater than in iron, being about 114 C.G.S. units for a load of 10 kilos on a wire of 0·8 mm. diameter, and 67 for a load of 6·6 kilos. For a force of 21 units no critical point exists. Experiments on a permanently strained iron wire show that for magnetising forces ranging from 0·03 to 0·3 there is no critical point, and all the resulting curves are identical. There is, however, considerable difference in the observations taken during loading and those taken on unloading. For greater magnetising forces the curves cease to be identical and the maximum increase the permeability becomes less and less until for a certain force the curves begin to cut the load line. As the force increases beyond this value the point of cutting approaches the origin and the curves begin to cut the load line in two points. Further increase of force to 3 C.G.S. units causes the first point to disappear and the second point recedes from the origin. Finally, with sufficiently high magnetising force, the second point cannot be reached before the wire breaks, and the curve lies entirely below the load line. With nickel the curves for very minute forces, like those of iron, are exactly the same for different values of the force, but they lie below the load line, *i.e.*, the permeability is diminished by loading; there is no difference, however, in the loading and unloading curves. Beyond a certain value of the force the identity of the curves ceases, and that part of the curve near the origin bulges towards the load line. For a force a little over 21 C.G.S. units, the permeability begins to increase with load, and the curve cuts the line in one point, which point recedes from the origin as the force increases.

Mr. SHELFORD BIDWELL said that Prof. J. J. Thomson, reasoning from the change of length by magnetisation, had predicted a Villari point in cobalt when compressed, and this was verified experimentally. On applying similar reasoning to nickel, he (the speaker) did not expect to find a Villari point, and both Sir W. Thomson and Prof. Ewing had searched in vain for one. In some experiments not yet completed, he had examined the behaviour of nickel, both loaded and unloaded, when subjected to various magnetising forces. These show that the metal always contracts when magnetised. For no load the contraction at first increases with the magnetising force, but attains a maximum. With a moderate load the contraction is less for small forces, but for larger forces becomes equal, and then exceeds the contraction of the unloaded wire. For greater loads, the contraction is always less than when unloaded for all values of the force.

"On Bertrand's Idiocyclophanous Prism," by Prof. S. P. THOMPSON, D.Sc. This hitherto undescribed prism is a total reflection, one made of calc spar, which shows to the naked eye the rings and crosses such as are seen when a slice of spar is examined by convergent light in a polariscope. The spar is cut so that the light after the first reflection passes along the optic axis, and, after a second reflection, emerges parallel to the incident light. The rings and brushes are present in pairs, but two pairs may be seen by tilting the prism to one side or the other. This was demonstrated before the Society. Prof. Thompson also exhibited a similar prism cut from quartz. Owing to the feeble double refracting of the substance, no conspicuous rings could be seen, but when examined by the lantern traces of such rings were visible.

"On the Shape of Movable Coils used in Electrical Measuring Instruments," by Mr. T. MATHER. The object of this note is to determine the best shape of the horizontal section of swinging coils such as are used in D'Arsonval galvanometers, electro-dynamometers, wattmeters, &c. Assuming constant period and constant moment of inertia about the axis of rotation, it is shown that for zero instruments the best shape of the section is two circles tangential to the direction of the deflecting field at the point about which the coil turns. A table accompanies the paper, in which various forms of section are given, together with their relative deflecting moments per unit moment of inertia; the coils being taken of equal lengths and the current density being constant From this table it appears that ordinary D'Arsonval coils only give about 45 per cent. of the maximum deflecting moment, and ordinary Siemens's dynamometers from 40 to 53 per cent. The various assumptions made in the paper are shown to be justifiable in commercial instruments, and the modifications necessary in special cases are pointed out.

Mr. C. V. BOYS said he had, when working at his radio-micrometer, arrived at a shape similar to that recommended in the paper. He also noticed a peculiar relation time for all shapes where the length parallel to the axis of rotation is great compared with the breadth. Suppose a coil of any dimensions, then another coil ot half the breadth and double the length, and cross-section will be dynamically, electrically, and magnetically the same as the original, for the moment of inertia, the electric resistance, and the enclosed magnetic field are equal. The above relation is also true when the breadth is not small, if the cross-pieces be thickened near the axis so as to make their moment of inertia proportional to their length. He enquired whether the author had considered the subject of grading movable coils; he, himself, was of opinion that, unlike fixed galvanometer coils, the wire near the axis should be thicker than that further away.

The PRESIDENT remarked that in 1881 Prof. Perry and himself exhibited a wattmeter at the Society of Arts, whose movable coil somewhat resembled one of those in the paper which gave a deflecting moment of 95 per cent. of the maximum. In designing the instrument they had felt that the ordinary method of using a comparatively large swinging coil was not the best, and this led them to the shape adopted.

NEW PATENTS—1890.

3805. "Improvements in electrical terminals." W. BRIERLEY, (Communicated by H. Arld, Germany.) Dated March 11.

3839. "Improved receiving apparatus for cable telegraphy." P. B. DELANY. Dated March 11.

3841. "Automatic apparatus for compensating variations of current in electric conductors." SIEMENS BROTHERS AND CO., LIMITED. (Communicated by A. M. Taylor, India.) Dated March 11.

3842. "A circuit breaker for secondary currents from electrical transformers." SIEMENS BROTHERS AND CO., LIMITED. (Communicated by A. M. Taylor, India.) Dated March 11.

3860. "Improvements in electric light fittings." D. HALPIN and I. A. TIMMIS. Dated March 11.

3900. "Improvements in insulation and cooling of electrical nductoria." L. PYKE and H. T. BARNETT. Dated March 12.

3913. "Improvements in alternate current transformers." G. KAPP, W. C. JOHNSON, and S. E. PHILLIPS. Dated March 12.

3924. "Improvements in electric batteries." H. H. LAKE. (Communicated by the Crosby Electric Company, United States.) Dated March 12. (*Complete.*)

3937. "Improvements in electric flash signalling lanterns and apparatus in connection therewith." W. S. RAWSON and C. S. SNELL. Dated March 13.

3947. "Improvements in the manufacture of light emitters or illuminants for electric or other lamps." J. CLEGG. Dated March 13.

3963. "Improvements in and relating to electrical switches." W. SCOTT. Dated March 13.

3969. "Improvements in switchboards for stations of electrical supply." SIEMENS BROTHERS AND CO., LIMITED. (Communicated by A. M. Taylor, India.) Dated March 13.

3984. "Improvements in or connected with shades, globes, or glasses for electric or other lights." A. DUVAL and H. NELSON. Dated March 13.

4000. "Improvements in electric regulators." H. PIEPER, Fils. Dated March 14.

4004. "Electric excitation of vacuum tubes or other electric discharge paths and condensers in connection therewith." H. T. BARNETT. Dated March 14.

4011. "An improved electrical apparatus for periodically ringing bells, or sounding alarms or signals and registering the same." F. H. BERRY. Dated March 14.

4025. "Improvements relating to electric incandescent lamps." A. A. GOLDSTON. Dated March 14.

4028. "Improvements in transmitters for electric telephones." C. L. W. FITZGERALD. Dated March 14.

4053. "Improvements in safety devices for high pressure electrical currents and indicating apparatus in connection with same." B. M. DRAKE and J. M. GORHAM. Dated March 15.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

1535. "Improvements in the construction and working of dynamos." I. A. TIMMIS. Dated January 28. 8d. Consists in the switching in automatically of one or more resistances at some convenient position or positions. 4 claims.

2137. "Improvements relating to magnetic telephony." E GWOSDEFF. Dated February 6. 8d. Claim:—The improvements in magnetic telephony described and characterised by the employment of two diaphragms, one of which is of iron, and arranged between the bobbins of two horseshoe magnets; the other of non-magnetic material, and of a diameter greater than the first, and connected to the centre of the iron diaphragm by one or more rods made of non-magnetic material, the point of attachment of these rods being at the centre of the non-magnetic diaphragm when the apparatus is to serve as a transmitter, but at a distance from the centre when the apparatus is used as a receiver, the bobbins of the magnets being in all cases connected together in such a manner that the current resulting is equal to the sum of the currents induced in each pair.

2252. "Improvements in apparatus for measuring electric currents." J. W. KING. Dated February 8. 6d. Claims:—The spiral shape of needle which may be of any section and placed in any position relative to the electro-magnet and pole piece which may be found best for the special purpose for which the instrument is used.

6628. "Improvements in laying and insulating underground mains for conveying electricity." W. H. SCOTT and PARIS and SCOTT. Dated April 18. 8d. Relates to the use for insulating and separating the conductor or conductors, of troughs, blocks, or tubes split or whole of any incombustible and insulating material such as earthenware, brick, glass or cement; these enclosing the conductor will be enclosed in iron or other metal troughs or tubes and the interstices between the blocks or tubes of incombustible insulating material are filled in with any fusible or semi-liquid non-conductor of electricity such as pitch, tar, resin, paraffin, wax or any other suitable fusible or semi-liquid non-conductor, or a suitable mixture of any of the above substances; so that the spaces between the conductor and the iron containing troughs or tubes is almost filled in with the non-combustible insulated material which is cheap and indestructible, and may be made of considerable thickness, the fusible or semi-fluid insulating material simply filling up, and on a leak occurring melting through the heat produced and probably sealing up the leak. 3 claims.

15775. "Improvements in electro-dynamic and dynamo-electric machines." C. F. WINKLER. Dated October 8. 8d. Has for its object to provide a machine which will require little current and a small quantity of copper to create a magnetic field of given strength, or in other words to provide a machine having as high an efficiency as possible. 15 claims.

15821. "Improvements in the method of electrolytically reducing plates of metallic salts to a metal state to 'form' the electrodes of secondary or storage batteries." S. C. C. CURRIE. Dated October 8. 8d. Consists in increasing the effective area of the electrical conducting material of the plates during the reduction to a metallic state, by causing the reduction to commence over the entire surface and gradually work its way through the plate in the line of cleavage or crystallisation, thereby materially lessening the time required to reduce the plates, and giving as a product plates of a superior character for use as the electrodes of a secondary or storage battery. Further consists in supporting and firmly holding the plates during their electrolytic reduction, whereby superior plates are produced. 7 claims.

16036. "Improvements in galvanic batteries." W. E. IRISH. Dated October 11. 8d. Claims:—1. In the employment of an amalgamated phosphor zinc, or a magnesium zinc or a common zinc electrode further amalgamated with a composition of mercury and tallow. 2. In arranging negative plates in both the inner and outer containing vessels so that the positive electrodes and the walls of the porous vessel intervene between them thereby reducing the resistance. 3. In the employment of supplemental electrodes of iron or of other suitable material for taking up the dissolved zinc, said supplemental electrodes being arranged outside of the positive plate and connected therewith by metallic connections so as to form a pair of elements in the one solution, whereby when the circuit of the battery is closed after being open some time the two electrodes are brought nearly to the same potential in consequence of the supplementary iron electrodes being covered with the zinc deposited thereon, thus reducing the resistance of the cell by the increased positive surface, the counter electromotive force being inconsiderable. 4. In the use of solutions which are partially regenerated by chemical action within the cell, and which save the rapid wasting of the positive element and prevent the formation of salt crystals on the electrodes; and, 5. In the covering of the battery solutions with a suitable oil or paraffin wax which will prevent the escape of fumes from the battery and prevent the slapping over of the solutions. 15 claims.

16648. "An improved electric railway system." M. WHELESS and S. E. WHEATLEY. Dated October 22. 8d. The object of the invention is a system of propelling cars by electricity, which consists, substantially, in causing electro-magnets, placed in a conduit, to open the line in the conduit, and thereby circuit the dynamo current through the motor on the car. 5 claims.

17118. "Improvements in and relating to electrical transformers or converters." L. PAGET and C. J. KINTNER. Dated October 29. 8d. Relates particularly to apparatus for the regulation of such systems, and in such a manner that the amount of energy required at the primary or generating source shall be governed or regulated in accordance with the amount of energy which is to be utilised in the secondary circuit or circuits. 13 claims.

17781. "An improvement in electric switches." W. WHITE. Dated November 7. 6d. Relates to a simple and inexpensive construction of electric switch so arranged that in one position it makes effective contact for closing the circuit to which it is applied, and that, when it is moved a little from that position, it automatically makes a rapid and complete break of contact. 2 claims.

18010. "Improvements in incandescent electric lamp holders and reflectors." I. A. TIMMIS. Dated November 12. 6d. Claims:—1. The use of a convex silvered glass reflector, substantially as and for the purposes described. 2. The use of a holder constructed to hold the reflector close to the lamp bulb, substantially as and for the purposes described. 3. The use of a convex silvered glass reflector having a rim of clear or coloured glass, substantially as and for the purposes described.

18051. "Improvements in and relating to electric signalling apparatus, chiefly designed for use in hotels and other buildings." H. H. LAKE. (Communicated from abroad by E. Morgan, of America.) Dated November 12. 1s. 1d. The object of the invention is to provide reliable, simple, and efficient means for transmitting the required signals to the central office, insuring that the signals shall be received in their proper order, and that one signal or call shall be attended to before another is received. 22 claims.

CORRESPONDENCE.

Tinned Copper Wire.

Referring to your leading article, *re* the above, contained in this week's issue, there is one class of fault to which this wire is subject which does not appear to have been discussed—viz., the *brittleness* of some specimens. Frequently faults have come under my notice which are attributable solely to this cause, especially in the thin branch leads to incandescent lamps. The wire has evidently been partly broken through in the process of running and jointing, and has afterwards become entirely disconnected.

I have also noticed hard and soft places in the same coil of wire when perfectly new, which necessitated the greatest of care in making the joint, in order to prevent fracture.

This I attribute, either rightly or wrongly, to overheating in the process of tinning, the tin and copper forming an alloy, and the wire being thus partly converted into brass. I am strengthened in this belief by the fact that, if broken while new, the section at the fracture shows that the tin has penetrated to a considerable depth into the copper.

F. W. Cooke, A.I.E.E.

March 31*st*, 1890.

Dynamo and Motor Design.

The so-called "Authorised Abstract" of the discussion on the above subject which you publish in last week's issue, in so far as reference is made to my remarks, is incomplete and misleading. I trust, therefore, you will allow me space to briefly state the true purport of what I said in reference to the action of the convolutions being commutated, and the effect of the core being well laminated in decreasing the divergence between generator and motor. I pointed out that when a wasteful current is generated in the short-circuited coils this current is obviously of the same direction as the Foucault currents in the iron core, and consequently opposes the motion, whether the machine is running as a motor or as a generator, and that it could never assist in the case of a motor, as Mr. Swinburne says it does in his paper.

I then pointed out that these currents and the Foucault currents in the core decrease the magnetic flux in the case of a generator and increase it in the case of a motor, and that these two actions account for the observed divergence in the E.M.F. generated in the armature windings in the two cases.

When there is no wasteful current in the short-circuited coils (which is the case in a good machine with brushes in the position of non-sparking), and the core of the armature is well laminated and insulated, the divergence between generator and motor is reduced to a minimum, and is very small.

From the above it appears that not only is the best possible generator the best possible motor, but that the better the machine the less is the divergence from complete reversibility.

W. B. Sayers.

Progress of Electric Lighting.

The following is an account of 4 months' supply of current, from 1st December, 1889, to 28th March, 1890, by a London supply company to a large hotel. As the light seems to be cut off nearly every day in the morning I have given the account, reckoning from 3 p.m. each day to 12 midnight. In the 4 months the supply was cut off 62 times, and was out 96 hours between 3 p.m. and 12 p.m. As an example of the intervals, the following will be amusing:—

December 5th, 1889:
Out at 7.10 a.m., on at 10 a.m.
Out at 3.10 p.m., on at 5.15 p.m.
Out at 5.35 p.m., on at 8.5 p.m.

January 13th, 1890:
Out at 4 p.m., on at 4.20 p.m.
Out at 4.25 p.m., on at 7.40 p.m.

January 20th, 1890:
Out at 3.5 p.m., on at 3.10 p.m.
On and off from 4.30 p.m. to 6.15 p.m.

March 3rd, 1890:
Out at 5.30 p.m., on at 5.35 p.m.
Out at 6.0 p.m., on at 7.45 p.m.

The account is far from satisfactory, so I will refrain from mentioning any names, but sincerely hope they are ashamed of their pranks and will endeavour to improve the supply. I have had a daily account kept and can guarantee its accuracy.

Trusting that the next 4 months will be better,

Periodicity.

The Physiological Effects of Currents.

In your next issue you will probably publish the paper read last Thursday before the Institution of Electrical Engineers by Messrs. Harries and Lawrence, comparing the physiological effects of continuous and alternating currents.

As an example of their experiments, a continuous current of 10 milliampères was passed through the human body without discomfort, and then the alternating current from the secondary of an induction coil (which is a discontinuous current) produced great discomfort when the instrument employed measured only 2 or 3 milliampères.

It is only fair that the principal fallacy of their conclusions should be shown at the same time that your journal goes forth to the world disseminating the error.

The instrument employed measures the "effective" current (a kind of average over the period of an alternation). The discomfort, however, measures the *maximum* value of the current during an alternation. With a well-made alternating dynamo the maximum current is about $1\frac{1}{2}$ times the effective current. But with the discontinuous secondary current, obtained by breaking the primary circuit of an induction coil, the maximum current rises to many times (I estimate 20 to 50 times) the effective current. Thus the current which caused discomfort was probably 20 to 50 times the current which was measured.

George Forbes.

March 31*st*, 1890.